

Reassessing the Role of Alternative Manure Management in California's Methane Reduction Strategy

DRAFT



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CalCAN is a statewide coalition that advances state and federal policy to catalyze the powerful climate solutions offered by sustainable and organic agriculture. We use policy to move California agriculture towards a system that is increasingly resilient and just. More information available at calclimateag.org.

To produce this analysis memo, authors consulted with dairy industry advisors and dairy producers. CalCAN greatly appreciates all who took the time to provide valuable input and assistance with the drafting of this analysis.

Cover image: Year-around compost barn funded by the Alternative Manure Management Program

EXECUTIVE SUMMARY

California's Alternative Manure Management Program (AMMP) supports dairy and livestock operations to reduce liquid and anaerobic manure management with practices that can achieve significant methane reduction and simultaneous improvements in various other environmental and agronomic outcomes. Facilitating wider adoption of alternative manure management practices is a highly effective way for the state to make progress towards multiple climate and environmental targets and requirements. However, as this report by CalCAN details, the state has not fully analyzed this multibenefit role of AMMP practices or considered how coordinated interagency planning and increased support could maximize the program's impact.

The California Air Resources Board's (CARB) 2022 [Analysis of Progress toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target](#) projected that alternative manure management practices would make a modest contribution to California's methane reduction goals. This report revisits those conclusions and shows where updated and expanded analysis is needed to capture a more accurate and comprehensive picture of the methane-reduction potential of alternative manure management practices. In reviewing the data and methodologies used for the CARB 2022 analysis, we identify how updates to AMMP implementation, tracking, and reporting can improve impacts and allow for better program analysis for state planning.

This report also proposes scenarios where alternative manure management could play a larger and more strategic role in meeting the state's methane targets, water quality, healthy soils, and organic transition targets. To conduct our analysis and support claims, we draw upon scientific literature, technical and policy reports, state agency data, and interviews and collaboration with dairy producers, dairy industry technical assistance providers, and other relevant experts. While we do not attempt to create in-depth modeling of AMMP practices that would be needed for a fuller understanding, we call on the relevant state agencies to conduct this analysis in partnership with external experts.

KEY FINDINGS:

- **The AMMP scenarios in CARB's 2022 analysis do not capture the potential role alternative manure management practices could play in California's methane targets.** Section 2 discusses the limitations and opportunities for updating the data, metrics, and methodologies used for AMMP in the 2022 analysis. Further, the 2022 analysis other AMMP scenario modelling assume various trends limiting potential reductions, but consideration of newer data, research, and broader state policies warrants revisiting those assumptions and considering more ambitious scenarios. Section 2 also identifies ways the state could enhance AMMP impacts
- **If 50–75% of California's dairy industry adopted alternative manure management practices, methane reductions could approach the additional 4.4 MMTCO₂e needed to meet SB 1383 targets.** These scenarios apply the same methodology as CARB's 2022 analysis used for enteric methane strategies. These scenarios are not predictions or based on current trends. Instead, they help illustrate the upper limits of possible alternative manure management reductions. (Section 3)
- **Using updated calculations, AMMP is the fourth most cost-effective California Climate Investment program tracked by CARB.** CARB's cost-effectiveness analysis underestimates AMMP by making an unjustified assumption of calculating DDRDP emissions with a 10-year project lifespan and AMMP with a five-year project lifespan. Evidence from producer surveys and technical assistance providers suggests that most AMMP projects last beyond five years, and a 10-year calculation is likely appropriate for AMMP. (Section 4)
- **Alternative manure management offers key co-benefits that support broader state goals/targets related to water quality, healthy soils, and organic transition.** The co-benefits of alternative manure management could play a vital role in meeting various state targets and regulatory requirements beyond methane reductions: helping dairies comply with the State Water Board's draft Dairy Order by reducing nitrogen loading; and supplying compost needed to meet the state's organic transition and healthy soil practice targets (set by AB 1757). (Section 5)

POLICY RECOMMENDATIONS:

Based on our analysis and findings, we offer the following recommendations to fully realize and understand the potential of alternative manure management and to enhance AMMP's effectiveness, scalability, and integration into broader environmental mandates.

Improve Cross-Agency Modeling and Planning

- **Establish an interagency task force** including CARB, CDFA, the State Water Resources Control Board, CalRecycle, and relevant external experts to reassess the full potential of AMMP and related practices. This group should coordinate scenario modeling that accounts for methane, nitrogen, water quality, and soil health impacts.

Update Modeling Assumptions and Program Evaluations

- **CARB should update AMMP's project lifespan assumptions to 10 years** to align with DDRDP.
- **CDFA should conduct a survey** of AMMP recipients with completed projects, i.e., those that have passed the 5 years of required reporting to CDFA, to assess the persistence rate of different AMMP practices

Update Emission Reductions Reporting Metrics While Improving Equitable Access

- **Expand required manure emissions inventories in manure methane programs applications to the facility's full herd**, not just the portion of the herd within the project boundary.
- **Utilize per-animal and full facility reduction metrics** for program evaluation and modelling.
- **Prioritize full facility percent reduction and per-animal reduction** in the ranking of AMMP of project selection. This is a more size and type-neutral approach than using per-project reductions

Increase Support for Expanded Adoption and Stacked Practices

- **CARB should update the AMMP calculator** to (1) allow applicants to report more than one primary practice, and (2) allow for projects to specify when they apply to different practices to different portions of the facility.
- **Direct technical assistance providers to stack funding for AMMP with federal and other sources**, to allow more projects to implement multiple practices.

Address Technical, Regulatory, and Knowledge Barriers

- **CDFA should expand funding for pre-application and post-award technical assistance**, including design, permitting, and composting expertise, including funding to support the training of new AMMP technical assistance providers.
- **Streamline compost permitting and manure-to-compost marketing regulations**, drawing on reports from Sustainable Conservation¹ and reports from Sustainable Conservation and the Manure Recycling and Innovative Products Task Force.²

Facilitate AMMP Practices That Maximize Methane and Co-Benefit Impacts

- **Invest in research, incentives, and market infrastructure to increase adoption of existing and emerging AMMP primary and supporting practices that achieve high methane reductions and/or co-benefits**, e.g, adding biochar to compost piles,³ vermifiltration, advanced separation, and expanding pasture management.

¹ Sustainable Conservation. Compost: Enhancing the Value of Manure. (2017). <https://suscon.org/wp-content/uploads/2017/10/Sustainable-Conservation-Manure-Compost-Report.pdf>

² California Department of Food and Agriculture (CDFA). Manure Recycling and Innovative Products Task Force (MRIP) Final Report. (2022). https://www.cdafa.ca.gov/oefi/research/docs/MRIP_FinalReport.pdf

³ Harrison, B. P., Moo, Z., Perez-Agredano, E., Gao, S., Zhang, X., & Ryals, R. (2024). Biochar-composting substantially reduces methane and air pollutant emissions from dairy manure. *Environmental Research Letters*, 19(1), 014081. <https://doi.org/10.1088/1748-9326/ad1ad2>

CONCLUSION:

The state must revisit its modeling of alternative manure management to reflect the full potential of these practices in reducing methane and delivering environmental co-benefits. This effort should be a multi-agency collaboration between CARB, the State Water Resource Control Board, the California Department of Resources Recycling and Recovery (CalRecycle), the California Department of Food and Agriculture (CDFA), other relevant agencies, and a stakeholder group of experts that includes those with experience in modeling manure management's methane, water quality, and air quality impacts as well as other related topics such as soil health and organic agriculture. A more comprehensive, collaborative, and scenario-driven analysis will provide a stronger foundation for policy decisions, funding allocations, and future program design.

1. Introduction

A. Background

According to CARB, livestock emit approximately 70% of California's agricultural sector greenhouse gases (GHGs).⁴ Livestock emissions in the state peaked in 2012 at 23.9 million metric tons of carbon dioxide equivalent (MMT CO_2e) and have decreased by 3.0 MMT CO_2e (12.6%) to 20.9 MMT CO_2e as of 2022,⁵ partially due to a decrease in total livestock population and partially due to the implementation of methane reduction techniques. Livestock emissions are almost entirely methane (CH_4), generated from enteric fermentation and manure management. CARB calculates that livestock generate more than half of the state's total CH_4 emissions, mostly coming from dairy operations. In 2016, SB 1383 (Lara) established Short-Lived Climate Pollution (SLCP) reduction targets. It required CARB to implement a Short-Lived Climate Pollutant Reduction Strategy to achieve these targets. For the dairy and livestock sector, CARB has set the target at 9.0 MMT CO_2e below 2013 levels.

The Dairy Digester Research and Development Program (DDRDP), created in 2015, was initially the state's sole strategy for reducing methane emissions associated with dairy production. In 2017, SB 859 acknowledged that a diversity of dairy methane management practices, including anaerobic digesters and nondigester strategies, could effectively reduce greenhouse gas emissions. The nondigester strategies described included scrape conversion, open solar drying and composting of manure onsite, conversion of dairy operations to pasture-based management, and solid separation technologies, helping support the development of the Alternative Manure Management Program (AMMP), which provides funding to reduce the amount of volatile solids entering anaerobic conditions conducive to methane formation. The program funds anaerobic digester projects to capture and use biogas. Then, in 2017, SB 859 directed CDFA to establish the Alternative Manure Management Program (AMMP), which provides funding to reduce the amount of volatile solids entering anaerobic conditions conducive to methane formation. Alternative manure management practices include flush-to-scrape conversion, solid-liquid separation with solar drying or composting, and increased time on pasture. In 2023, the U.S. Department of Agriculture (USDA) Advancing Markets for Producers (formerly known as Partnerships for Climate Smart Commodities) created an opportunity for the California Dairy Research Foundation (CDRF) to collaborate with CDFA to launch the [Dairy PLUS Program](#) to implement practices that reduce both methane emissions and nitrogen surplus at dairies.

B. CARB's 2022 Report

In 2022 (as required under SB 1383), CARB released a report, "[Analysis of Progress toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target](#)," that projected that, without additional funding, the dairy and livestock sector would achieve just over half of the annual methane emissions reductions necessary to achieve the target by 2030. Their analysis in Table 1 (copied below from the 2022 report) shows that most of the reductions so far have come from anaerobic digesters and decreases in total herd populations,⁶ while a much smaller reduction has come from AMMP. After accounting for reduced herd populations, CARB projected that the state must reduce an additional 4.4 MMT CO_2 from manure management and enteric sources.

⁴ California Air Resource Board (CARB). (2024). *California Greenhouse Gas Emissions from 2000 to 2022: Trends of Emissions and Other Indicators*. https://ww2.arb.ca.gov/sites/default/files/2024-09/nc-2000_2022_ghg_inventory_trends.pdf

⁵ Ibid. pg 30

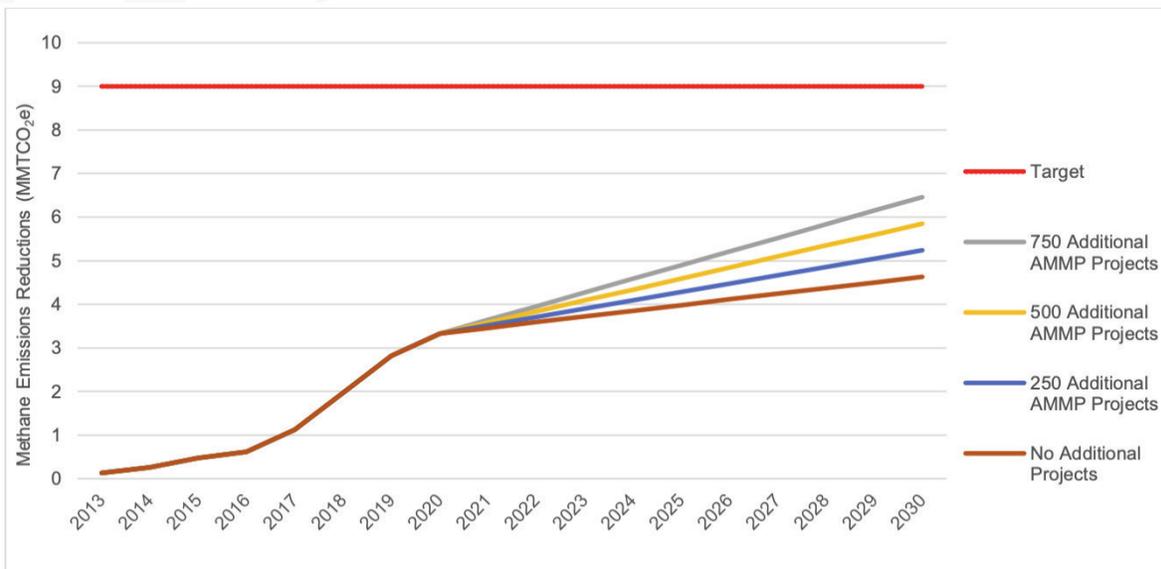
⁶ Reductions in total herd populations within the borders of CA may or may not represent actual reductions in U.S. dairy herd emissions; it may simply represent movement of dairies and/or cows out of state, in which case this may be a case of leakage, rather than actual global emission reductions.

Table 1: CARB's Estimated California Dairy and Livestock Methane Emissions Reduction by the End of 2022

Reduction Type		Number of Projects Funded through FY 2019-20	Expected Emissions Reductions Through 2022 (MMTCO ₂ e)
Population Change		Not Applicable	1.3
Anaerobic Digester	State-funded (DDRDP)	118	1.8
	Privately funded	5	0.1
Alternative Manure Management Practices	State-funded (AMMP)	115	0.2
	Privately funded	40	0.1
Total		278	3.5

Figure A below is CARB's projection in the 2022 report of the additional methane reduction potential of AMMP through 2030. CARB projected that funding an extra 750 AMMP projects would lead to California falling short of reaching the 2030 methane reduction goals set by SB 1383. The projection led CARB to conclude that alternative manure management practices alone cannot achieve methane reduction targets and that methane digesters and enteric strategies would be necessary to achieve SB 1383 goals.⁷

Figure A: CARB's 2022 Projected Annual Dairy and Livestock Sector Methane Emissions Reductions through 2030 Resulting from Implementing Additional AMMP Projects



⁷ On page 13 of its 2022 analysis, CARB writes “Based on this approach, at least 210 anaerobic digestion and 210 alternative manure management projects are necessary to achieve the remaining 4.4 MMTCO₂e in methane emissions reductions. However, future project types may vary depending upon available incentives and operator preference. If only dairy digester projects were implemented—which are about ten times as effective at reducing emissions than alternative manure management projects—over 230 projects would be necessary to achieve this level of emissions reductions. With respect to alternative manure management practices, based on currently funded projects and reduction trends observed to date, staff’s analysis indicates that the state would be unable to achieve the 2030 dairy and livestock sector target through deployment of alternative manure management practices alone.”

CARB's methodology for creating Figure A was to take the total reported annual methane reduction of all the AMMP projects funded by CDFA to that point, divide that total by the number of projects to get an average, and multiply that average by 250, 500, and 750.⁸ In this report, we show that this methodology did not fully account for the CH₄ reduction potential of alternative manure management practices, and we propose a different approach.

CARB also calculated the cost-effectiveness of AMMP and DDRDP in its 2022 report and used those calculations to inform various incentive funding scenarios. In calculating the cost-effectiveness of those two programs, CARB assumed that AMMP projects would have half the lifespan of DDRDP projects (five years rather than 10). While this difference reflects different program length in reporting requirements, evidence does not support that AMMP project lifespans are only five years, and this report presents updated AMMP cost-effectiveness calculations.

C. Outline and Summary of Sections

This report is organized as follows:

[Section 2](#) analyzes the trends that have shaped AMMP's average reductions so far and argues that CARB's methodology of assessing the methane reduction potential of alternative manure management practices by projecting these trends is incomplete.

[Section 3](#) creates scenarios for alternative manure management practices using the same methodology as CARB's 2022 report applied to enteric solutions, showing that widespread adoption of alternative manure management practices across the industry could play a significant role in methane reduction.

[Section 4](#) shows that CARB uses a 10-year lifespan projection for DDRDP projects to calculate total emissions reductions and cost-effectiveness, but only uses a 5-year lifespan projection for AMMP. This section shows those assumptions are not justified and that newer research and observations support longer AMMP projections. The Section calculates new AMMP cost-effectiveness.

[Section 5](#) explores how the co-benefits of alternative manure management practices could drive increased producer demand and state support. The practices could play a vital role in meeting the new water quality requirements outlined in the Draft Dairy Order (October 2024) and producing the compost needed for the state to achieve organic agriculture transition and soil health practice targets. The section gives some examples of how to model the compost production potential of alternative manure management and calls on the state to do more in-depth scenario modelling of all co-benefits.

⁸ The CH₄ emissions reductions of AMMP projects are estimated using the CARB AMMP calculator, which has been developed and updated by CARB throughout the existence of AMMP based on scientific literature, the Intergovernmental Panel on Climate Change (IPCC) livestock protocol, and feedback and input from experts.

2. Identifying Limits and Opportunities to Update Data, Metrics, and Methodologies in AMMP Projection Scenarios Shows Potential Expanded Role in Methane Reduction

CARB's 2022 report projected AMMP's future methane reductions by multiplying current average project reductions by hypothetical future project counts (250, 500, and 750), assuming continued reduction trends. While these projections provide a helpful baseline, and conservative assessments using existing averages are understandable, this section will show why reassessments with different methodologies and data are needed, and why it is necessary to revisit CARB's 2022 conclusion that alternative manure management can only play a minor role in meeting California's methane reduction targets.

This section analyzes the factors that have shaped variation in AMMP project outcomes and demonstrates that average reductions are the product of policy and funding decisions and implementation dynamics, not inherent limitations in the practices themselves. Section 2A examines sources of variation across AMMP projects, including differences in herd size, housing types, practice stacking, and use of emerging technologies. It also highlights limitations in the current AMMP calculator that affect reported outcomes. Section 2B explores how shifts in incentives, program design, and regulatory drivers, such as new water quality mandates, could shape future implementation and methane reductions. Together, these analyses point to the need for CARB to adopt a more dynamic, scenario-based approach when evaluating the potential of alternative manure management practices.

CARB's 2022 analysis used AMMP and DDRDP data from the agency's California Climate Investments (CCI) Database of Implemented GGRF Projects obtained in December 2020. For our analysis, we used the most recent CCI dataset, which includes projects through the 2022 application period,⁹ and expanded it with CDFA's publicly available AMMP¹⁰ and DDRDP¹¹ datasets for projects funded up to the 2023 application period.¹² In addition, CDFA was able to provide CalCAN with additional anonymized or aggregated AMMP and DDRDP data to allow some assessment of the overall impacts and variation between projects and practices, which is linked and summarized when referenced. We obtained the herd size data from the [California Dairy and Livestock Database](#), which was made publicly available for the first time in August 2024.

The emissions reduction estimates from these datasets all come from AMMP and DDRDP project applications and may not represent the real-life emissions reductions, which are unknown without extensive monitoring. AMMP project applicants use CARB's AMMP Benefits Calculator Tool to estimate baseline and post-project CH₄ emissions.¹³ It is important to note that some manure management experts dispute aspects of the calculator;¹⁴ methane reduction rates can vary based on various conditions, and improper management can reduce reduction rates. However, the purpose of this analysis is not to call the underlying data into question but rather to suggest more robust and accurate analysis of that data.

⁹ This is the most recent CCI data available as of May 2025. Note that the CCI data reports the year in which the project received funding while the CDFA data reports the year in which the application period was held. As such, for example, projects funded by the 2022 application opening and awarded in 2023 are reported in the CDFA data for 2022 and the CCI data for 2023.

¹⁰ CDFA AMMP Project Level Data obtained on April 30 2025 https://www.cdfa.ca.gov/oefi/AMMP/docs/AMMP_Project_Level_Data.pdf

¹¹ CDFA DDRDP Project Level Data obtained on April 30 2025 https://www.cdfa.ca.gov/oefi/DDRDP/docs/DDRDP_Project_Level_Data.pdf

¹² In April 2025, CDFA announced the awardees from the 2024 project application period, but at time of publication had not yet incorporated the 2024 projects into the publicly available full project-level datasheets for each program.

¹³ Calculator can be downloaded from CARB's webpage here: https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/cdfa_ddrdp_finalcalculatortool_7-19-2024.xlsx

¹⁴ See for example discussion on incorporating bedding and recycled manure into mechanical separator calculations in Chapter 3 of [Research and Technical Analysis to Support and Improve the Alternative Manure Management Program Quantification Methodology](#)

A. Wide Variance in AMMP Project Outcomes Reflects Differences in Baseline Emissions, Practice Implementation, and Program Design

CARB's 2022 projections of AMMP's future potential assume that the program's average methane reductions per project will remain relatively static. But as this section shows, average project-level reductions are not a fixed attribute of the practices themselves, they are the outcome of multiple variations across projects: baseline emissions, housing and herd types, the number and type of practices adopted, and how fully each practice is implemented within a dairy. These variations reflect both the flexibility and limitations of data, metrics, and methodologies that have been used to assess AMMP.

To highlight the large difference in per-project reductions, Table 2 shows that the top 10% of projects average over 5,600 MTCO₂e in annual reductions, more than three times the overall program average of 1,679 MTCO₂e. The bottom 10% of projects average just 194 MTCO₂e. The table in [Appendix 1](#) provides project-level data, including herd size and descriptive notes, for a sample of high- and low-performing AMMP projects.¹⁵

Table 2. Differences in Methane Reductions Across AMMP Projects (MTCO₂e)

Group	Average Annual CH ₄ Reduction (MTCO ₂ e)
Top 10% of Projects	5,660
Overall Program Average	1,679
Bottom 10% of Projects	194

Table 3 updates CARB's 2022 report methodology with the latest CDFA project-level data by calculating the overall average CH₄ reduction for all AMMP projects and each of the top three most popular primary AMMP projects.¹⁶ As in CARB's 2022 report, flush-to-scrape is the practice with the highest average reduction, achieving nearly twice the program average. Multiplying the average reduction of each category by 250, 500, and 750 projects allows for comparison with [Figure A](#) from CARB's report. This disaggregation shows how the program's future impact could vary depending on the mix of practices supported. While practice type helps explain some of this variation, baseline emissions, herd size and composition, scope implementation, and stacking of practices also drive outcomes.

Table 3: Estimated Annual Methane Reduction Potential of AMMP Projects by Practice through 2023 (MT CO₂e)

Number of Projects	All Practice Average	Compost Bedded Pack	Solid Separation	Flush-to-Scrape
1 (average)	1679	1516	1573	2965
250	419,750	378,955	393,250	741,250
500	839,500	757,911	786,500	1,482,500
750	1,259,250	1,136,866	1,179,750	2,223,750

¹⁵ Names of sample dairies have been removed and replaced with a # ID.

¹⁶ As done by CARB on pg. 17 of the 2022 Analysis.

i. AMMP Projects Have Lower Baseline Emissions than DDRDP

AMMP project emissions are calculated from an estimate of the volume of total volatile solids entering a lagoon through the manure stream before and after the implementation of the AMMP project. Logically, operations and projects with lower starting total volatile solids entering lagoons have less potential to reduce emissions. AMMP was created in part to provide an option for California's small and medium-sized, organic, and pasture-based dairies, where installing a digester with assistance from DDRDP may not have been economically feasible or practical for their style of manure management. Though data limitations preclude definitive conclusions, the participation of these operations in AMMP likely brings down the average per-project reductions when compared to DDRDP. Thus, projections and assessments prioritizing per-project emissions can disadvantage many smaller, organic, and pasture-based operations. CARB acknowledges the important role AMMP plays in reaching these operations, so it is worth pursuing other approaches to scenario modeling, such as full facility percent reductions and per-cow reductions.

Smaller operations have smaller manure streams and less methane to reduce. Using data provided by CDFA for projects through the 2023 application period, the average number of livestock per project is 1,786 for AMMP and 6,209 for DDRDP.¹⁷ These averages refer to the number of livestock in the project boundaries rather than the total size of the operation.

Limitations of AMMP Calculator and Available Project Data Prevent More Accurate Assessments

AMMP projects do not require applicants to report methane reductions as a percentage of the facilities total herd emissions. Projects are only evaluated based on the portion of the herd and manure stream covered by the grant-funded practice. This limits the analysis of methane reduction differences.

Proposal: Require applicants to complete an emissions inventory for the facility's entire herd and estimate project-level reductions as a share of that baseline. This would allow more consistent evaluation across dairies of different sizes and support more strategic funding decisions.

Similarly, limitations in the AMMP calculator prevent more accurate analysis of the role of multiple and stacked practices including frequency of occurrence, the factors that enable it, and the extent to which stacking practices contribute to emissions reduction compared to other factors. Projects are limited to selecting only one primary practice in the AMMP calculator, and the tool assumes each is applied uniformly across the operation. This creates a mismatch between reported outcomes and actual implementation, particularly in projects that combine multiple upgrades across different housing types.

Proposal: Update the AMMP calculator to allow applicants to include more than one practice and adjust for which practices are applied to different portions of an operation.

¹⁷ Unpublished data shared in personal communication.

Pasture-based dairies typically report very low baseline emissions under CARB's Quantification Methodology (QM) because cows on pasture deposit manure directly onto fields without anaerobic storage. This significantly limits the methane reduction potential that can be credited through AMMP, even if the farm adds infrastructure to manage manure during seasonal confinement or in specific areas of the operation.

Similarly, projects with high numbers of heifers, dry cows, or open lots of lactating cows will have lower baseline emissions. CARB's QM calculates 70% of manure from animals in open lots is deposited on land, with only 30% requiring collection. By contrast, lactating cows housed in free stalls in the AM deposit 80% of their manure on concrete surfaces that feed into anaerobic storage. Additionally, heifers and dry cows produce less manure per day than milking cows. Thus, there is a lower methane reduction potential for any project involving large numbers of heifers, dry cows, or open-lot lactating cows.

Availability of Additional Metrics Would Enable More Equitable and Comprehensive Evaluation of Methane Reductions

Because AMMP serves a wide range of dairy sizes and facility types, project-level reductions alone are not adequate for analyzing program effectiveness. Including other metrics, such as methane reduction per animal or as a percentage reduced from total operation baseline emissions, may allow for a fairer, more complete basis for project comparison and overall program analysis. While the latter would require substantial additions to AMMP's application requirements and Benefit Calculator, applicants already calculate per-animal reductions for the herd within the project's boundary. Per-animal assessments help identify high-impact projects across different operation scales and avoid biasing funding toward large herds with inherently higher absolute emissions. Per-animal metrics could also help identify particularly cost-effective or well-designed projects, even when total reductions are modest.

Proposal: CDFA and CARB should publish per-animal reduction values (for both the project herd and the total operation herd) for AMMP and DDRDP projects, and incorporate per-animal and other metrics into scenario modeling.

ii. Project Implementation Further Shapes Reductions

Table 4 illustrates that AMMP projects report substantial differences in percent effectiveness, even for the same practice and baseline emissions. Table 4 uses data reported in AMMP applications calculated from only cows in project boundaries and shows the lowest, highest, and average percentage reductions reported for the three most common AMMP practices.¹⁸

¹⁸ Unpublished data provided by CDFA to authors in personal communication.

Table 4: AMMP project manure management CH₄ emissions reduction from baseline (2019-2023; only for animals in project boundary)

Primary practice	Lowest % reduction	Highest % reduction	Average % reduction
Solid separation	0% ¹⁹	87%	26%
Compost-bedded pack barn	28%	92%	69%
Flush-to-scrape	24%	85%	62%

The lack of reported and collected data limits the analysis of why there are such large discrepancies in percentage reductions from baseline emissions for AMMP projects that use the same practice. However, this section will explore one possibility: the stacking of practices.

AMMP projects that fund multiple or stacked practices likely achieve greater percent reductions of methane. For example, two dairies of the same size might each receive AMMP funding to install a sloped screen separator. One may install it across a manure stream containing multiple flushed free stall facilities, while another may install it on one free stall. Some projects also combine multiple practices, like flush-to-scrape conversion with a separator, while others install only one piece of equipment. The scope of implementation and the percentage of the herd affected play a major role in project outcomes.

As an example of stacking practices, Dairy #32 in the [Appendix 1](#) table is the AMMP project with the highest reported annual emissions reductions (11,118 MTCO₂e) as of 2023. Dairy #32 used AMMP to convert from a flush to a vacuum scrape system and installed two solid separators to allow for drying and composting of the vacuumed slurry. With a herd size of 4,500, Dairy #32 reported an 83% reduction in CH₄ emissions.

Differences in existing site layout, drainage, equipment access, and match funding capacity can influence how efficiently a project can use an AMMP grant. The Small Dairy Climate Change Research report commissioned for CDFA confirms this, documenting how physical and financial constraints affect implementation scope and technology adoption.²⁰

Overall, AMMP's flexibility enables participation from a broader range of dairies, but it also results in substantial variation in practice combinations and implementation levels. This diversity is not a flaw but a defining feature of the program, and one that complicates simplistic comparisons with more uniform strategies like digesters. Scenario modelling of AMMP could explore policy and funding scenarios that facilitate more dairy stacking AMMP practices and achieving higher methane reductions.

iii. Advanced Technologies Show Higher Performance and Merit Broader Consideration

CARB acknowledged in its 2022 analysis the potential for higher methane emission reductions through wider adoption of "advanced manure management practices" but did not include this possibility in its AMMP scenarios or assessment. Many of these practices either need California field trials to prove viability and/or lack general methane reduction data from non-biased sources. The Dairy Plus Program is

¹⁹ There is one listed project with 0% CH₄. The project's description proposes replacing a low-functioning outdated separator system with a new separator to allow for a significant increase of solids removal. In reality, this project likely did achieve CH₄ reductions, but the AMMP calculator was not able to account for the reduced efficiency of the outdated separator, so the application showed equal starting and ending separation rates. Currently, the AMMP calculator has an option to adjust for baseline separators with degraded efficiency, but this option was added more recently. This example gives more evidence of the unreliability of relying on the averages of self reported data of past AMMP projects to calculate future scenarios.

²⁰ Mullinax, D., Meyer, D., Sumner, D. (2020). An economic evaluation of strategies for methane emission reduction effectiveness and appropriateness in small and large California dairies. https://www.cdca.ca.gov/oefi/research/docs/CDFA_SmallDairyResearch_FINAL_Report.pdf

supporting some of these advanced manure practices (Table 5), and the USDA grant funding the program is also funding monitoring and evaluation. As this data becomes available in the near future, it may be appropriate to incorporate these options into future projection scenarios.

The AMMP first included advanced solid-separation practices, including using flocculants and/or bead filters, and vermifiltration, in its 2022 grant round, and has supported weeping walls since the start of the program. However, due to the introduction of the Dairy Plus Program beginning in 2023, AMMP does not yet have funded examples of advanced solid separation practices, as applicants opted to leverage the increased funding through the Dairy Plus Program for these more extensive and expensive technologies. One example of a vermifiltration project that was awarded for AMMP in 2022, but chose to decline their award to pursue additional funding through the Dairy Plus Program in 2023, had an estimated reduction of 7,813 MTCO₂e annually. Other examples of past AMMP projects that installed weeping walls are listed in the table in [Appendix 1](#). These include Dairy #22 and #27, which are among the AMMP projects with the highest reported methane reduction rates and cost-effectiveness.

Table 5 uses CDFA's reported data on the Dairy Plus AMMP track [list of awarded practices](#).²¹ Table 5 shows that funding 750 Dairy Plus-style projects could yield approximately 3.7 MMTCO₂e in reductions, approaching the 4.4 MMTCO₂e in additional reductions that CARB estimated the dairy and livestock sector would need to achieve by 2030. These projections may not reflect realistic scenarios, but they highlight the importance of incorporating advanced manure management practices into comprehensive scenario modeling.

Table 5: Projections from Dairy Plus (AMMP track) Project Reductions MMT CO₂e.

Number of Projects	All Practice Average	Vermifiltration	Weeping Wall	Advanced Separation
1	4,939	5,706	4,584	3,967
250	1,234,804	1,426,500	1,146,000	991,713
500	2,469,608	2,853,000	2,292,000	1,983,425
750	3,704,250	4,279,500	3,438,000	2,975,250

There are also other emerging advanced manure management practices not currently supported but may see future support. For example, recent research suggests that broader inclusion of practices like biochar-composting should be considered in AMMP-practice incentives scenario modeling. In a trial on a California dairy, researchers found that co-composting with wood-derived biochar reduced methane emissions by 58%, volatile organic compounds by 61%, hydrogen sulfide by 67%, and NO_x by 70%, due to biochar's porous structure and oxygen-enhancing properties that suppress anaerobic conditions during the thermophilic composting phase.²² Another study found methane reductions up to 80% in peak stages, though nitrous oxide responses varied based on biochar properties.²³ Harrison et al. (2022) modeled scenarios in which California dairies already operating digesters with solid separators replace manure stockpiling with biochar-composting. They found that this combination could improve statewide CH₄ mitigation by 29%.²⁴

²¹ Accessed May 7, 2025. Version used last updated November, 2025. https://www.cdca.ca.gov/oefi/dairyplus/docs/2023_DairyPlusAMMP_ProjectsAwarded.pdf

²² Harrison et al. (2024 A)

²³ Harrison, B. P., Gao, S., Thao, T., Gonzales, M. L., Williams, K. L., Scott, N., Hale, L., Ghezzehei, T., Diaz, G., & Ryals, R. A. (2024). Methane and nitrous oxide emissions during biochar-composting are driven by biochar application rate and aggregate formation. *GCB Bioenergy*, 16(1), e13121. <https://doi.org/10.1111/gcbb.13121>

²⁴ Harrison, Brendan P., Si Gao, Melinda Gonzales, et.al. (2022) Dairy Manure Co-composting with Wood Biochar Plays a Critical Role in Meeting Global Methane Goals. *Environmental Science & Technology*. 56 (15), 10992. <https://doi.org/10.1021/acs.est.2c03467>.

CDFA previously excluded biochar from AMMP eligibility on the grounds that its benefits were limited to soil carbon sequestration, but these recent field-scale studies show it can directly reduce methane during composting.²⁵ This evidence supports reconsidering biochar-composting as an eligible manure treatment and/or storage practice for separated or scrape collected solids.

There may be limitations to the widespread adoption of these newer practices. Vermifiltration can generate large volumes of compostable solids that may exceed a dairy's handling capacity, and scaling these systems remains a logistical and regulatory challenge. Advanced solid separation systems leave behind nutrient-rich effluent that requires careful storage or application, and in some cases produce solids with characteristics that complicate reuse.²⁶ Despite these constraints, scenario modeling could find appropriate ways to incorporate these practices into projections that reflect the full range of viable, field-tested strategies capable of helping the sector meet the state's 2030 methane targets.

B. Assessing Future Potential: How AMMP's Impact Could Grow Under Evolving Conditions

Future analysis of AMMP should explore different policy scenarios that increase per-project or program-wide methane reductions over time. Scenario-based modeling is needed to assess the role AMMP could play in achieving California's methane targets more accurately. Such modeling would allow agencies to test the impact of different policy scenarios and program design choices.

This section outlines three types of future scenarios that could lead to significantly higher methane reductions from AMMP-supported practices: (1) expanded program funding that enables practice stacking and implementation across larger portions of the herd; (2) greater producer demand and state interest in funding to meet water quality regulations, environmental justice outcomes, and organic transition and healthy soil practice targets; (3) and increases in average project effectiveness through prioritization and technical assistance. Together, these shifts would allow AMMP and related initiatives to scale beyond historical averages and play a larger role in meeting California's methane reduction targets.

i. Expanded Adoption Through Increased Funding

Limits in program funding and overall incentives for alternative management have shaped the scale of AMMP adoption and emissions reductions achieved to date. Increased funding would allow for more widespread access while allowing more dairies to increase practice stacking and implementation.

CDFA has regularly received more eligible applications than it can fund every year.²⁷ As noted by an AMMP technical assistance provider, in many Northern California counties, producers who were initially enthusiastic have stopped applying after repeated unsuccessful attempts, believing the odds are too low to justify the effort. In contrast, they reported that AMMP technical assistance in Sonoma and Marin Counties has ensured more steady applications and helped deliver highly effective AMMP projects that have drastically improved the local watershed. However, many in the region are still discouraged from applying because of the high chance of rejection.

²⁵ See CDFA AMMP New Management Practices Proposals Public Comments on Recommendations and Final Determination https://www.cdfa.ca.gov/oefi/ammp/docs/ammp_newpractices_final2021.pdf

²⁶ Zubair, M., Wang S., Zhang P. ... Cai W. (2020) Biological nutrient removal and recovery from solid and liquid livestock manure: Recent advance and perspective. *Bioresource Technology*, 301 <https://doi.org/10.1016/j.biortech.2020.122823>.

²⁷ <https://calclimateag.org/ammp/>

Further, AMMP's funding cap—currently \$750,000 per project and one project per operation—can limit the extent to which the program can support multiple practice adoption across an operation. Some applicants can leverage match funding or existing infrastructure to stretch grant dollars further, while others are prevented from maximizing practice adoption by the cap and one-grant limit. These limits help spread out AMMP's funding while demand is greater than availability, but growing awareness of the benefits of alternative management could lead to sufficient state, federal, or private funding to support widespread adoption, more practices per operation, and more advanced technologies and systems that can achieve higher reductions. Increasing availability of funds per operation could allow wider adoption across herds and stacking of practices.

Evidence Shows Lack of Funding Limits Per Dairy Reduction Potential

Producer interest in more comprehensive implementation is already evident. A Cal Poly evaluation found that 91% of AMMP recipients were somewhat or strongly likely to reapply. AMMP technical assistance providers and CalCAN have also heard directly from producers interested in expanding their projects.

For example, CalCAN spoke with a dairy producer from Stanislaus County and one from San Joaquin County who have received AMMP support to install manure separators and seen substantial benefits, and reported also wanting to secure funding to convert one of their freestalls to a compost bedded pack barn. They cannot re-apply to AMMP and have not been able to access other funds yet. In another example, CalCAN spoke with a Merced County dairy producer that used AMMP to install a compost bedded pack barn and reported they would apply again if possible to install a manure separator on their remaining free stall.

In many cases, the barrier is not interest but funding. These missed opportunities suggest that many dairies would achieve greater emissions reductions and other environmental co-benefits if they had access to adequate support.

Proposal: Expand permitted activities in CDFA's Climate Smart Agriculture Technical Assistance Program to allow technical assistance providers to assist producers with federal programs. This would allow TAPs to work with producers to stack AMMP with federal funds and maximize practice adoption.

More strategic coordination between state and federal funding streams could also help AMMP projects scale more effectively. Some AMMP awardees have successfully secured USDA Environmental Quality Incentives Program (EQIP) grants to expand their projects beyond what CDFA funds alone could support. Aligning timelines, simplifying application processes, and increasing technical assistance could help more producers "stack" AMMP with federal programs. Potential future federal legislation, like the Converting Our Waste Sustainably (COWS) Act²⁸ could open additional federal support for alternative manure management practices.

²⁸ <https://calclimateag.org/currentcampaigns/cows-act/>

ii. Increased Demand for AMMP Co-Benefits to Meet Water Quality Targets and Other State Goals

CARB's AMMP modeling focuses exclusively on methane reductions, omitting key co-benefits related to water quality, nitrogen management, and compost supply. As discussed in Section 5, AMMP practices can play an important role in meeting water quality requirements on dairies, while also producing compost needed to achieve the state's targets for organic acreage transition and healthy soils practice adoption.

The Draft State Water Board Dairy Order (October 2024) proposed more stringent nitrogen application requirements for dairies. AMMP practices, especially composting, can enable nutrient export and help comply with new requirements. Several AMMP and dairy stakeholders interviewed for this memo predict that the Dairy Order will drive increased interest and need for alternative manure management practices.

Similarly, a University of California convening of experts found that AMMP could help address environmental justice-centered concerns around greater concentration of herds and associated local water and air quality impacts. The report noted this in the context of the AB 32 (Nuñez, 2006) and SB 197 (E. Garcia, 2016) requirements that state GHG emission reduction efforts prioritize communities that are disproportionately impacted by climate change and public health threats.²⁹

At the same time, California has set ambitious goals to expand compost use statewide. The Nature-Based Solutions Climate Targets, established by AB 1757 (Garcia, 2022), call for transitioning 20% of cropland to organic management by 2045 and implementing healthy soil practices on an additional 140,000 acres per year. Both objectives rely on a significantly increased compost supply. AMMP-supported manure composting could help fill that gap. Furthermore, some AMMP producers we interviewed report reduced fertilizer costs due to the use of compost produced on-farm. This was especially important when fertilizer prices surged in 2021. Fertilizer prices have come down from the peak in 2022 but remain high, and producers continue to seek alternatives.³⁰ Pastured AMMP dairies have also reported improved forage quality from compost applications and the ability to extend the grazing season by a couple of weeks.

Yet these connections are not currently factored into CARB's scenario modeling. Both the state and producers may become more interested in alternative manure management as a strategy that simultaneously meets methane targets and other environmental and agronomic goals, increasing support and demand, and thus potentially increasing the overall future methane reductions the approach can achieve. A deeper discussion of these water and compost-related co-benefits follows in Section 5.

iii. Increasing Average Project Effectiveness

AMMP's reported methane reductions per project vary widely due to differences in practice selection, implementation scope, infrastructure constraints, and herd characteristics. While this variation reflects the program's flexibility and accessibility, it also means that some funded projects deliver significantly higher reductions than others. However, there may be opportunities to improve the future average methane reduction effectiveness of AMMP without compromising access for smaller or pasture-based dairies. Scenario modeling should take these possibilities into account.

²⁹ Elkind, E.N., Lamm, T. and Zelen, R. (2022) *Ahead of the Herd: Policy Solutions to Accelerate Livestock Methane Emissions Reduction in California*. UC Berkeley School of Law's Center for Law, Energy & the Environment and UCLA School of Law's Emmett Institute on Climate Change and the Environment,. <https://www.law.berkeley.edu/wp-content/uploads/2022/09/Ahead-of-the-Herd-September-2022.pdf>, p.g. 22.

³⁰ https://ycharts.com/indicators/fertilizers_index_world_bank

Proposed Avenues for Improving AMMP Effectiveness

The following recommendations come from AMMP technical assistance providers and researchers who helped review this memo and have extensive experience with the program.

Proposal: More technical assistance and project design support could help applicants implement practices more comprehensively across their herds or combine multiple strategies for larger reductions.

Proposal: As sufficient data is available, fund increased implementation of newer practices with high reduction rates, such as advanced separation systems, vermifiltration, and manure composting with biochar. Increasing the viability of these practices would also require addressing barriers outside of the scope of AMMP, including streamlining regulations of on-farm manure compost, ensuring demand for compost, and creating biochar supply chains.

Proposal: Improve metrics for prioritization of more effective AMMP applications, including requiring AMMP applications to complete an operation-wide emissions inventory of before and after proposed project. This would allow for CDFA to consider how well a proposed project reduces emissions per-cow from total baseline and prioritize more effective projects on a size-neutral basis.

3. Projecting AMMP Adoption Scenarios Across California Dairy/Livestock Herd

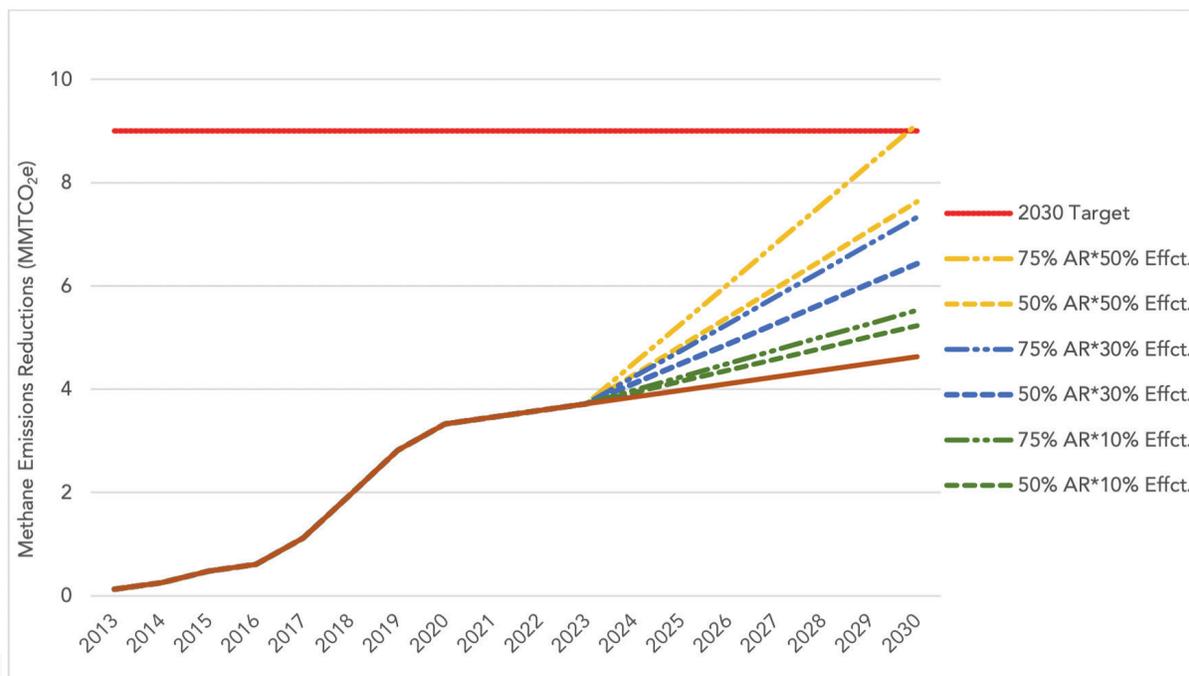
The assessment of AMMP in CARB's 2022 analysis, based on projecting future methane reductions from current averages, helps to understand conservative scenarios. However, the same 2022 analysis produced scenario projections where enteric methane feed additives would play a significant role in meeting the state's 2030 40% CH₄ reduction target despite considerable uncertainty and implementation barriers.

Given the wide accessibility of different manure management practices across different types of dairies, this section argues that AMMP practice projections with similar assumptions are equally appropriate.

A. CARB's Enteric Scenario Assumptions

CARB's 2022 analysis (Finding 1-5, pg. 26) concluded that "the dairy and livestock sector may fall short of the 2030 CH₄ target absent an enteric strategy and sufficient public funds." To reach this conclusion, CARB assumed the adoption of a feed additive with 30% enteric methane mitigation potential across ruminants in California beginning in 2024, with a linear adoption rate of roughly 11% per year, reaching 75% of the ruminant population by 2030 (pg. 28). CARB's Figure B illustrates alternative scenarios using varying assumptions for additive efficacy and adoption.

Figure B: From CARB's 2022 report (pg. 24) - Projected Annual California Dairy and Livestock Sector Enteric Methane Emissions Reductions through 2030 Under Various Feed Additive Adoption Rates (AR) and Methane Mitigation Effectiveness (Effct.)



As of early 2025, the Food and Drug Agency (FDA) has only approved one product, 3-NOP, as a feed additive that can make enteric methane reduction claims. It achieves average reductions of 20–40%,³¹ is not certified for use by organic dairy and livestock producers, and has uncertain consumer acceptance.³² Other additives, such as *Agolin* (10–20%)³³ are FDA-approved for general use but not for methane reduction claims, and a California study showed that feeding dairy cows grape pomace from the state's wine industry reduces methane by 10–11%.³⁴ In late 2024, CDFA approved Blue Ocean Barns' red seaweed (*Asparagopsis*) additive, which has shown average reductions of 52% and up to 90% in trials, but it is not yet FDA-approved, and the feasibility and environmental impacts of large-scale production remain uncertain.³⁵

While CARB's selection of 30% efficacy is plausible, the 50% scenario in Figure B is more speculative. Even the 30% scenario is ambitious: to achieve 75% herd adoption by 2030, 3-NOP would currently need to supply most of the market, potentially supplemented by other products. Although some studies show improvements in feed efficiency with 3-NOP, others do not,³⁶ and projections have shown that savings are unlikely to offset costs fully.³⁷ So, public or private incentives will be necessary absent regulation. For instance, one study found that cost neutrality would require payments of \$0.21 to \$0.42 per cow per day,

³¹ CARB 2022 Analysis, pg. 22

³² See recent consumer backlash against milk from dairies using 3-NOP in the UK, <https://www.euronews.com/green/2024/12/03/burping-cows-bovaer-and-boycotts-the-anti-methane-additive-thats-taking-social-media-by-st>.

³³ CARB 2022 Analysis, pg. 23

³⁴ Akter, A. et al. (2025) 'Grape pomace supplementation reduced methane emissions and improved milk quality in lactating dairy cows', *Journal of Dairy Science*, 108(3), pp. 2468–2480. <https://www.sciencedirect.com/science/article/pii/S0022030224014164>.

³⁵ Deelen, B. G. van. (2022, June 14). Feeding cows seaweed reduces their methane emissions, but California farms are a long way from scaling up the practice. *Inside Climate News*. <https://insideclimatenews.org/news/14062022/cow-seaweed-methane/>

³⁶ Pupo, M. R., Ferraretto, L. F., & Nicholson, C. F. (2025). Effects of feeding 3-nitrooxypropanol for methane emissions reduction on income over feed costs in the United States. *Journal of Dairy Science*, 108(5), 5061–5075. <https://www.sciencedirect.com/science/article/pii/S0022030225001456>

³⁷ Martins, L. F., Maigaard, M., Johansen, M., Lund, P., Ma, X., Niu, M., & Hristov, A. N. (2025). Lactational performance effects of 3-nitrooxypropanol supplementation to dairy cows: A meta-regression. *Journal of Dairy Science*, 108(2), 1538–1553. <https://www.sciencedirect.com/science/article/pii/S0022030225000219#cesec60>

and an average of \$128,000/year for a dairy with 1,000 milking cows.³⁸ Another study found that CO₂e needs to be priced at \$109/tonne to maintain a neutral net return from 3-NOP supplementation.³⁹ If CARB is willing to assume such ambitious adoption for enteric strategies, similar consideration should be given to alternative manure management practices.

B. Methodology: AMMP Broad Industry Adoption Scenarios

We applied CARB's scenario-based approach from its enteric analysis to alternative manure management. Table 6 presents scenarios that assume the adoption of alternative manure management practices across 50% or 75% of the California dairy sector anaerobic manure emissions with average methane reduction rates of 25%, 40%, 60%, or 75%.

Applying alternative manure management practices to 50 or 75% of the dairy industry's manure streams is a significant divergence from current trends, but may be possible with facilitative funding and policy conditions, as discussed in Section 2B. The justification for each of the methane reduction rates is as follows and uses averages calculated from CDFA data for AMMP projects 2019-2023:⁴⁰

- **25%** represents the lower bound. Using CDFA data on 2019-2023 AMMP reductions from baseline manure emissions (for animals in the project boundary), 25% is approximately the average reduction for solid separation projects, the AMMP practice category with the lowest average reduction rate.
- **40%** represents the approximate overall average percent reduction rate across all practices in the CDFA data.⁴¹
- **60%** represents a calculation of the average reductions of the top 10% most effective projects in the CDFA data, weighted according to the number of projects funded in each practice category.⁴²
- **75%** represents an aspirational goal. The non-weighted average of the top 10% most effective AMMP projects is 83%. These projects are mostly compost bedded pack barns on herds sized 1-1000, suggesting an unrealistic goal for industry-wide adoption. However, considering the emerging advanced manure management technologies and the various scenarios discussed in Section 2 of increased demand and support for alternative manure management, the 75% scenario is worth considering.

All scenarios assume an 8.0 MMTCO₂e baseline based on CARB's reported 2022 CH₄ emissions⁴³ from the manure stream of California's dairy cattle that use "wet" management practices.⁴⁴

³⁸ Pupo, M. R., Ferraretto, L. F., & Nicholson, C. F. (2025). Effects of feeding 3-nitrooxypropanol for methane emissions reduction on income over feed costs in the United States. *Journal of Dairy Science*, 108(5), 5061–5075. <https://www.sciencedirect.com/science/article/pii/S0022030225001456>

³⁹ Martins, L. F., Maigaard, M., Johansen, M., Lund, P., Ma, X., Niu, M., & Hristov, A. N. (2025). Lactational performance effects of 3-nitrooxypropanol supplementation to dairy cows: A meta-regression. *Journal of Dairy Science*, 108 (2), 1551. <https://www.sciencedirect.com/science/article/pii/S00220302>

⁴⁰ Unpublished data provided to authors via personal communication.

⁴¹ Rounded down from actual average of 41% [Reduction Estimates AMMP 2019 to Present.xlsx](#)

⁴² The CDFA data set includes 115 total projects, 73 solid separation projects, 34 compost bedded pack barn projects, and eight flush-to-scrape projects. Rounded up from the actual weighted average of 59.8%.

⁴³ From CARB's 2000-2022 GHG Inventory (2024 Edition) <https://ww2.arb.ca.gov/ghg-inventory-data#data>

⁴⁴ To calculate the emissions of the wet manure stream, we used the sum emissions of the following categories in CARB's Scoping Plan" data set of the GHG Inventory: dairy cows with anaerobic lagoons or anaerobic digesters and dairy cows and dairy heifers heifers with liquid/slurry management. We rounded down from actual total of 8.01 MMTCO₂e. Data set used found here as of July 25, 2025: https://ww2.arb.ca.gov/sites/default/files/2024-09/nc-ghg_inventory_scopingplan_all_00-22.xlsx

Table 6. AMMP Methane Reduction Scenarios

Projected Annual California Dairy Manure CH₄ Emissions (MMTCO₂e) Reductions Under Various Alternative Manure Management Practice Adoption Rates and Average Per Project Methane Reduction Rates

AMMP Practice Adoption Rate Across California's Current Anaerobic Manure Stream	25% Average Reduction Effectiveness ⁴⁵	40% Reduction Effectiveness	60% Reduction Effectiveness	75% Reduction Effectiveness
50%	1.0	1.6	2.4	3.0
75%	1.5	2.4	3.6	4.5

C. Analysis: AMMP Practice Industry-Wide Adoption Scenarios

CARB's 2022 analysis estimated that an additional 4.4 MMTCO₂e of methane reductions are needed by 2030 from the dairy and livestock sector to meet the state's SB 1383 goal. In Table 6, one scenario exceeds that target: 75% adoption rate of AMMP practices with 75% average reduction effectiveness. All these scenarios project alternative manure management playing a larger role in emissions reductions than projected by CARB.

It is important to emphasize that these scenarios do not represent projections of current trends but instead illustrate what may be technically feasible under facilitative conditions, including policy, funding, and programmatic implementation shifts. This reapplication of CARB's 2022 methodology for enteric feed additives scenarios projections shows how similar modeling assumptions could be applied to AMMP to ensure consistency across strategies.

Our findings differ notably from those presented in the 2020 CDFA-funded "2020 Small Dairy Climate Change Research report commissioned for CDFA," primarily due to differences in underlying assumptions, methodologies, and the scope of scenarios modeled.⁴⁶ The authors of that report created significantly more in-depth scenarios for alternative manure management than CARB or this report. They employed a more conservative, feasibility-oriented methodology that projected adoption scenarios based on anticipated ongoing dairy industry consolidation, lack of adoption of some of the advanced practices discussed in our analysis, and continuation of incentive, economic, and policy structures that favor digesters over AMMP practices.

While acknowledging these valid constraints, our analysis explicitly explores more ambitious but plausible scenarios under facilitative regulatory, economic, and funding conditions that the Small Dairy Climate Change Research report did not model in depth. As discussed in Section 2B, these facilitative scenarios include increased demand to meet water quality regulations under the October 2024 Draft Dairy Order, greater demand for compost to achieve state soil health targets, and improved average AMMP reductions.

⁴⁵ From operation's baseline manure methane (for animals in the project boundary).

⁴⁶ Mullinax et al., (2020)

Both the Small Dairy Climate Change Research Report and the analysis in this memo have demonstrated the need for the state to consider a broader range of scenarios when assessing the potential of AMMP in planning for methane targets and other goals.

4. Cost-Effectiveness of AMMP

In CARB's 2022 analysis, they calculated the cost-benefit of AMMP and DDRDP on page 17. In Table 7, we updated that analysis with the most recent project-level data and expanded on it.

Table 7: Estimated Cost-Effectiveness of California Dairy and Livestock Methane Emissions Reductions through 2022

Program	State Investments (\$/MTCO ₂ e)	Private Investment (\$/MTCO ₂ e)	Total Investment (\$/MTCO ₂ e)
DDRDP (10 years)	\$9	\$20	\$29
AMMP (5 years)	\$74	\$16	\$90
AMMP (10 years)	\$37	\$8	\$45
Top 10% most effective AMMP (10 years)	\$14	\$5	\$19

CARB calculates the total CH₄ emission reduction for DDRDP using a 10-year lifespan, and AMMP uses a five-year lifespan. This decision was made because of an initial comment period held by CARB that suggested that some AMMP technologies may break down after five years. But now that AMMP has been implemented for more than five years, there have not been widespread reports of people abandoning AMMP practices. On the other hand, AMMP technical assistance providers have reported that dairies opt to repair separators when they break because of cost savings through reduced costs of bedding, slurry transportation, and/or reduced fertilizer purchases.⁴⁷ Further, a recent CalPoly evaluation revealed that 93% of the funded AMMP practices were maintained by the surveyed producers, with a 100% persistence rate for flush-to-scrape systems, a 96% persistence rate for solid separation systems, and an 86% persistence rate for compost-bedded pack barns.⁴⁸

In Table 7, when looking at AMMP CH₄ projections using a 10-year lifespan rather than a five-year lifespan, AMMP's cost-effectiveness improves significantly, especially when accounting for private investment. Table 7 also shows that Dairy Plus projects' cost-effectiveness has been higher so far than AMMP, suggesting that cost-effectiveness might improve if AMMP supports more advanced manure management practices.⁴⁹

⁴⁷ Personal communication. Betsy Karle, Dairy Farm Advisor, University of California Cooperative Extension Glenn County. 4/12/2025.

⁴⁸ Babin et al. (2024)

⁴⁹ More robust analysis of Dairy Plus funded practices is needed before more conclusively claiming they are more cost effective than other AMMP practices.

CARB should revisit the decision to calculate AMMP using a five-year projection. The decision should be an informed survey of AMMP recipients and technical assistance providers to determine the average life expectancy of an AMMP project, keeping open the possibility of assigning different averages for different practices and technologies.⁵⁰

Using the updated 10-year calculator for AMMP, the program rises to the fourth most cost-effective California Climate Investment program tracked by CARB on the basis of dollars per MTCO₂e reduced.⁵¹

5. Modeling AMMP Co-Benefits

Alternative manure management offers key co-benefits that support broader state goals and targets beyond methane reduction. More in-depth modeling of these co-benefits would allow the state to better plan for meeting those targets. The co-benefits of alternative manure management could play a vital role in meeting various state targets and regulatory requirements beyond methane reductions: helping dairies comply with the State Water Board's Draft Dairy Order by reducing nitrogen loading; and supplying compost needed to meet the state's organic transition and healthy soil practice targets (set by AB 1757). If there is increased demand and support for AMMP practice co-benefits, this could in turn increase adoption and methane reductions. A more integrated modeling approach would better reflect the role of these practices in meeting intersecting state mandates.

A. Water Quality Benefits

AMMP practices offer significant potential to mitigate dairy-related nitrogen pollution, a primary driver of groundwater contamination in California's dairy regions. As the Draft Dairy Order ratchets up regulatory requirements, it may increase demand from dairy producers for AMMP-supported practices that facilitate nutrient export and water quality compliance. While the Draft Dairy Order does not require or promote these practices explicitly, its emphasis on limiting land application of manure and encouraging off-site nutrient removal makes AMMP-supported methods increasingly relevant. This reinforces the need for CARB to coordinate with the State Water Board to model how AMMP can help meet not just climate goals, but water quality mandates as well.

i. Nitrogen Pollution and Dairy Groundwater Impacts

The Central Valley Dairy Representative Monitoring Program (CVDRMP) report found that groundwater beneath dairy operations in the Central Valley consistently exceeds water quality objectives for nitrates.⁵² Monitoring data from 2012–2018 across 42 dairies found nitrate concentrations surpassing regulatory thresholds at all sites, with about 94% of nitrate losses attributable to overapplication of liquid manure and wastewater on forage crops.⁵³ As CVDRMP notes, nitrogen surpluses at the whole-farm level are the primary cause of excessive land application, and achieving water quality targets will require expanded off-site nutrient export.⁵⁴ However, most manure on California dairies is stored and handled in liquid form,

⁵⁰ Another related concern is funding AMMP on dairies that may be at risk of closing within a few years (or at least less than 10). Small and mid-sized dairies are closing at a very high rate in the US and California and bearing significant political and economic shifts, the trend is likely to continue. Because AMMP funds a significant number of dairies that are not large enough to find digesters economically feasible, with current trends, there is a higher probability that an AMMP dairy will close within 10 years than a DDRDP dairy. However, this does change the recommendation: a survey of AMMP projects can help better inform average life expectancy.

⁵¹ California Climate Investments 2024 Mid-Year Data Update. https://ww2.arb.ca.gov/sites/default/files/2024-12/2024-CCI-Mid-Year_Update.pdf

⁵² Cativiela, J.P., Angermann T., Dunham T. *Summary Representative Monitoring Report*. (2019) Central Valley Dairy Representative Monitoring Program (CVDRMP). <https://leadershipcounsel.org/wp-content/uploads/2019/10/Dairy-report.pdf>

⁵³ Ibid. pg. 22.

⁵⁴ Ibid. pg. 23-24.

which is difficult and costly to transport. The CVDRMP report notes explicitly that the liquid fraction of manure is “almost never exported off-site due to the difficulty of doing so.”⁵⁵

ii. Regulatory Context: Draft State Water Board Dairy Order (October 2024)

The Draft Dairy Order proposes a comprehensive framework for regulating nitrogen discharges to groundwater from dairy operations. It emphasizes numeric nitrogen application limits based on groundwater protection standards and requires whole-farm nitrogen accounting and phased compliance schedules. While the Order does not explicitly endorse alternative management or composting, it does reference nutrient export and alternative uses of manure as necessary when application would exceed agronomic rates.⁵⁶ It also acknowledges composting as a potential strategy, citing CVDRMP's identification of its benefits and the barriers to adoption, such as air quality permitting and cost constraints.⁵⁷

In general, management systems that allow for more dry handling of manure can help reduce nutrient leaching risk by enhancing the export potential of manure solids due to easier transport.⁵⁸ The CVDRMP report emphasizes that composting stabilizes nitrogen, converting it into organic forms less prone to leaching and runoff. Composting also addresses pathogen concerns and weed seeds, enhancing the market value of manure solids and supporting nutrient export off-site.⁵⁹ Yet composting involves additional operational costs, air permitting challenges, and emissions of volatile organic compounds (VOCs) and ammonia, highlighting important economic and regulatory considerations.⁶⁰

Transitioning from wet (flush-lagoon) systems to dry manure handling can significantly reduce nitrogen loading to groundwater. Dry management systems, such as solid-liquid separation technologies, reduce nutrient leaching risk by enhancing the export potential of manure solids due to easier transport and improved marketability.⁶¹

AMMP and Water Quality Improvements in the North Coast

According to an interviewed dairy advisor, alternative manure management is improving the health of a watershed located between Sonoma and Marin counties. In the watershed, three projects have received funding through both AMMP and partnership funds and a fourth was supported solely by partnership funds. Each project involved the construction of new housing, either compost bedded pack barns or freestalls with scrape or vacuum systems, for animals that were previously kept on open dry lots. These animals typically generate approximately 1.6 cubic feet of solid and liquid manure per day, amounting to about 1,760 cubic feet annually per animal. Given an average of 25 wet weather days per year in the region, these projects collectively prevent around 40,000 to 50,000 cubic feet of manure from becoming runoff, instead capturing and redirecting nutrients for on-farm use through dried manure and compost. Preliminary data collection show improvements in nitrogen and phosphorus levels in the watershed.

⁵⁵ Ibid. pg. 25.

⁵⁶ State of California State Water Resources Control Board Draft Order WQ 2024-00xx. (October, 2024). https://www.waterboards.ca.gov/public_notices/petitions/water_quality/docs/r5-2013-0122/a2283bdrftordr.pdf_pg_C-7

⁵⁷ Draft Dairy Order, 2024, pg. 54

⁵⁸ Kaffka, S., Williams, R., Marvinney, E., & Smith, J. (2022). Manure Nutrient Recovery, Removal, and Reuse on California Dairies., pg. 55-56. https://www.cdfa.ca.gov/oefi/research/docs/cbc_manure_nutrient_report.pdf

⁵⁹ CVDRMP, 2019, pg. 32–34

⁶⁰ CVDRMP, 2019, pg. 34

⁶¹ Kaffka, S., Williams, R., Marvinney, E., & Smith, J. (2022). Manure Nutrient Recovery, Removal, and Reuse on California Dairies., pg. 55-56. <https://>

iii. Advanced Nutrient Management Technologies

Some advanced manure treatment technologies present promising opportunities for enhanced nutrient removal and recovery:

- **Advanced Separators with Flocculants:** The Trident Nutrient Recovery System significantly reduces soluble nutrients, reducing the nitrogen (organic N and nearly all the ammoniac N) in the liquid effluent by about half and up to 90% of the phosphorus.⁶²
- **Vermifiltration:** BioFiltro vermifiltration removes 80-90% of the volatile solids from flushed dairy wastewater, producing a finished compost of retained solids and worm casings. The remaining liquid effluent has reduced nitrogen by 40-90% and phosphorus by 20-80%. Though effectiveness varies significantly based on management, this technology can be a highly effective approach for producing compost and managing nutrients.⁶³

For these two practices, the USDA grant supporting the Dairy Plus Program is funding University of California researchers to collect on-dairy data on changes in nitrogen and salt surpluses. This monitoring and evaluation will help assess how the practices contribute to California's water quality goals.

iv. Water Quality Conclusions and Recommendations

Although implementation faces economic and regulatory hurdles, alternative manure management practices offer significant benefits by stabilizing and exporting nutrients, thus protecting groundwater. AMMP helps dairies shift away from liquid systems that are difficult to export, opening up new pathways to reduce whole-farm nitrogen surpluses and limit overapplication. As the state adopts stricter regulatory requirements under the Draft Dairy Order, demand for these practices may increase. CARB, the State Water Resources Control Board, and CDFA should collaborate to assess how AMMP-supported practices can help meet water quality mandates and adjust methane reduction modeling to account for these co-benefits and the potential for broader adoption of AMMP practices.

B. Compost Production, Soil Health, and Soil Carbon Sequestration

California has established ambitious climate and agricultural targets that underscore the critical role of compost in enhancing soil health and sequestering carbon. The 2024 Nature-Based Solutions (NBS) Climate Targets, mandated by AB 1757, set forth goals to transition 10% of the state's annual and perennial croplands to organic management by 2030, increasing to 20% by 204 (approximately 1.9 million acres),⁶⁴ and adopt healthy soil practices on 140,000 new acres each year starting in 2030. Achieving these targets necessitates a substantial increase in compost availability, as compost application is a cornerstone of both organic farming and soil health initiatives.⁶⁵

Alternative manure management can play an essential role in bridging this compost supply gap. Utilizing manure-derived compost addresses multiple objectives: reducing greenhouse gas emissions from dry storage, enhancing soil carbon sequestration, and supplying the compost necessary for the state's organic agriculture expansion and soil health improvement efforts. Incorporating the co-benefits of compost production into the evaluation framework of alternative manure management practices will allow future scenario modeling that provides a more comprehensive understanding of how the practices can simultaneously help meet the state's methane reduction and NBS climate targets.

www.cdfa.ca.gov/oefi/research/docs/cbc_manure_nutrient_report.pdf.

⁶² Kaffka et al. (2022), pg. 55–56

⁶³ Kaffka et al. (2022), pg. 57–59

⁶⁴ The 2024 California NBS Climate Targets report estimates 9.8 million acres of cropland. California's Nature-Based Solutions Climate Targets, pg. 15.

⁶⁵ Administration of Gavin Newsom. (2024). *California Natural Resources Agency, California's Nature-Based Solutions Climate Targets: As Required by Assembly Bill 1757 (2022, C. Garcia)*. <https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/Californias-NBS-Climate-Targets-2024.pdf>.

We created the scenarios in Table 8 to illustrate that alternative manure management practices can play a significant role in meeting the compost needs of the state. These are basic scenarios that show that the state should pursue in-depth modeling to best inform planning.

Table 8: Estimated Statewide Finished Compost Production from Dairy Manure Under AMMP Industry-wide Adoption and Solids Separation Scenarios

Practice Adoption Rate Across CA Dairy Industry	25% Manure Volatile Solids Diverted Towards Composting	40% Manure Volatile Solids Diverted Towards Composting	60% Manure Volatile Solids Diverted Towards Composting	75% Manure Volatile Solids Diverted Towards Composting
50%	1.2 million tons	1.9 million tons	2.9 million tons	3.6 million tons
75%	1.8 million tons	2.9 million tons	4.3 million tons	5.4 million tons

To create Table 9, we mimicked the methodology we applied to methane reduction scenarios in Section 3 and Table 7. The "Practice Adoption Rate" in Table 8 represents scenarios where California dairies adopt alternative manure management practices across 50% and 75% of the industry's entire anaerobically managed wet manure stream. See Section 3B for an explanation of why we used the 25%, 40%, 60%, and 75% separation rates. We assumed a starting point of 37.2 million tons of manure annually based on CDFA and USDA estimates of approximately 1.7 million dairy cows statewide and an average manure output of 120 pounds per cow per day. Lastly, to find the final tons of compost produced, we accounted for the loss of mass through the composting process by multiplying the diverted volatile solids by 25.7%, approximately the same rate that CARB uses in the AMMP calculator.⁶⁶

The full formula for calculating the tons of compost reported in Table 8 is as follows: 37.2 million tons (CA annual dairy manure) × Adoption Rate × Separation Effectiveness × 0.257 (loss of mass through composting process).

The scenarios in Table 8 show that alternative manure management could produce a large portion of the compost needed to meet California's organic transition and soil health objectives. As discussed in Section 3, these high adoption rates are ambitious but help illustrate what might be possible under facilitative funding, economic, and policy conditions.

This potential for increasing compost supply and application is especially relevant in dairy-producing regions, where proximity to compost sources could reduce transportation costs and barriers to use. Importantly, the climate benefits of applying this compost, through soil carbon sequestration, are additive to AMMP's methane reductions and are not currently accounted for in any modeling. Including these benefits in future projections would offer a more accurate picture of AMMP's potential role in helping California meet its interrelated methane, soil health, and organic agriculture goals.

⁶⁶ The AMMP calculator multiplies the mass of solids composted by 0.256854 to estimate the mass of the final compost produced. More specifically, the AMMP calculator multiplies the total volatile solids sent to compost feedstock by a 0.39 conversion factor and a 0.6586 factor to convert from dry tons to wet tons.

6. Policy Recommendations: Expanding the Role of AMMP to Meet Climate, Water, and Soil Health Goals

AMMP is already achieving meaningful methane reductions and delivering environmental co-benefits. However, this analysis shows that current modeling underrepresents the potential role that alternative manure management practices can play in meeting California's agricultural climate targets and regulatory requirements. Further, strategic reforms could enhance AMMP's effectiveness, scalability, and integration into broader environmental mandates.

To fully realize and understand the potential of alternative manure management, we propose the following recommendations, informed by our analysis, stakeholder input, and complementary literature.

Improve Cross-Agency Modeling and Planning

- 1 **Establish an interagency task force** including CARB, CDFA, the State Water Resources Control Board, CalRecycle, and relevant external experts to reassess the full potential of AMMP and related practices. This group should coordinate scenario modeling that accounts for methane, nitrogen, water quality, and soil health impacts.

Update Modeling Assumptions and Program Evaluations

- 2 **CARB should update the minimum project lifetime assumptions in AMMP's quantification methodology to 10 years** to align with DDRDP.
- 3 **CDFA should conduct a survey** of AMMP recipients with completed projects, i.e., those that have passed the 5 years of required reporting to CDFA, to assess the persistence rate of different AMMP practices.⁶⁷

Update Emission Reductions Reporting Metrics While Improving Equitable Access

- 4 **Expand required manure emissions inventories in manure methane programs applications to the facility's full herd**, not just the portion of the herd within the project boundary.
- 5 **Utilize per-animal and full facility reduction metrics** for program evaluation and modelling.
- 6 **Prioritize full facility percent reduction and per-animal reduction** in the ranking of AMMP of project selection. This is a more size and type-neutral approach than using per-project reductions

⁶⁷ While the program already does conduct post-project completion reporting for up to five years following project closeout, including collecting information on whether the project practice is still operational and utilized, additional periodic surveys or status updates may be required and could inform the project lifespan increase.

Increase Support for Expanded Adoption and Stacked Practices

- 7 **CARB should update the AMMP calculator** to (1) allow applicants to report more than one primary practice, and (2) allow for projects to specify when they apply to different practices to different portions of the facility. Without these updates, assessments of AMMP cannot accurately account for projects that implement multiple practices.
- 8 **Direct technical assistance providers to stack funding for AMMP with federal and other sources** to allow more projects to implement multiple practices.

Address Technical, Regulatory, and Knowledge Barriers

- 9 **Expand funding for AMMP pre-application and post-award technical assistance**, including design, permitting, and composting expertise, including funding to support the training of new AMMP technical assistance providers.⁶⁸
- 10 **Streamline compost permitting and manure-to-compost marketing regulations**, drawing on reports from Sustainable Conservation and the Manure Recycling and Innovative Products Task Force.

Facilitate AMMP Practices That Maximize and Methane Co-Benefit Impacts

- 11 **Invest in research, incentives, and market infrastructure to increase adoption of existing and emerging AMMP practices and supporting practices that achieve very high methane reductions and or improve co-benefits**, e.g, adding biochar to compost piles, vermifiltration, advanced separation, and expanding pasture management.

7. Conclusion

This report has analyzed the significant current role and large potential alternative manure management practices in meeting targets and goals set by California: methane, water quality, healthy soil practice adoption, and organic transition. We recommend that CARB, CDFA, the State Water Board, CalRecycle, and other relevant stakeholders collaborate on an analysis of AMMP practices that includes: (1) scenario modeling that explores possible shifts policy and other factors that would facilitate higher practice adoption rates and methane reductions; (2) methane metrics broader than average project reductions, including percent reductions from facility baselines and per-cow emissions; (3) updated data where possible and appropriate, e.g. accounting for project's stacking practices; and (4) similar scenario modelling and analysis of AMMP's co-benefits as they relate to state goals. A coordinated cross-agency and external stakeholder reassessment of AMMP's technical potential and policy needs would support deeper, more accurate integration into the state's climate and environmental planning.

In parallel, CARB should update the assumed project lifespan of AMMP practices from five years to ten years. This adjustment is supported by current evidence from CDFA surveys and technical assistance providers. A longer duration more accurately reflects observed persistence of practice changes and would improve modeled cost-effectiveness.

⁶⁸ During the development of this report, CDFA established a new contract with the University of California Agriculture and Natural Resources (UC ANR) for \$570,000. This AMMP-specific project is to develop a curriculum and learning modules to better train and onboard technical assistance providers, improving capacity and expertise to work with interested operations on planning, application, and project implementation. Topics include basics of conservation management, GHG and short-lived climate pollutant legislation, California's dairy sector, housing and management, AMMP practices, manure impacts to air and water quality, and grant activities, including application and project management.

⁷⁰ https://www.cdfa.ca.gov/oefi/research/docs/MRIP_FinalReport.pdf

Additional policy updates discussed in this memo, including updates to the AMMP QM and Benefits Calculator, expanded technical assistance, and supporting broader use of dairy manure compost, can support broader alternative manure management implementation and better alignment with water, air, and soil policy goals.

Appendix 1: Table of Sample AMMP Projects

The table referenced in Section 2 as Appendix 1 can be found in this linked Google sheet https://docs.google.com/spreadsheets/d/1WC1b7pRTm_xoUXMnv0LYXe0mZeoEL5UPjKo4midvShg/edit?gid=0#gid=0.

The table, created by CalCAN, lists a sample of awarded AMMP projects and includes project-level data from CDFA and CARB's CCI database and includes a "herd size" column that reports the total number of livestock reported in the California Dairy and Livestock Database (CADD) for the facility implementing the project (including cattle outside of the AMMP project limits). The names of each operation have been replaced with ID #s.

Appendix 2: AMMP Practice Separation Rates

To understand the effectiveness of AMMP practices, we can also look at the standard rates that CARB uses in the AMMP calculator. The following are the rates at which CARB's calculator assumes that each practice keeps volatile solids out of anaerobic manure lagoons.

Weeping wall	65%
Stationary screen	30%
Vibrating screen	15%
Screw press	25%
Centrifuge	50%
Roller drum	25%
Belt press/screen	50%
Polymer (flocculants)	80% (on top of the separator used)
Full Flush-to-scrape	90%
Compost bedded pack barn	90%
Aerated vermicomposting system	90%

