Sent via Email

August 21, 2026

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Re: Petition for Rulemaking to Add Dams and Reservoirs as Reporting Entities Under the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions

Dear Mr. Wockner,

Thank you for submitting a petition for rulemaking ("Petition") on behalf of Tell the Dam Truth (TTDT), Patagonia, Friends of the River (FOR), Rios to Rivers, Save The World's Rivers, California Trout (CalTrout), Ridges to Riffles, and the Center for Biological Diversity (the Center) on March 25, 2026, to the California Air Resources Board (CARB or Board). CARB acknowledged receipt of the Petition on March 26, 2026. We appreciate that petitioners agreed to extend the deadline for response to the Petition to August 23, 2026.

Petitioners requested that CARB initiate a rulemaking and other appropriate actions to repeal existing language exempting hydropower facilities from CARB's Mandatory Greenhouse Gas Reporting Regulation (MRR) reporting requirements (California Code of Regulations title 17, section 95101(f)(1)), and require reporting of greenhouse gas (GHG) emissions from dam and reservoir systems that generate electricity or supply water used in California.

The Petition notes that CARB is California's state agency "charged with monitoring and regulating sources of emissions of greenhouse gases that cause global warming in order to reduce emissions of greenhouse gases."[1] As mentioned in the Petition, the

[1] Petition at p. 7, available at *https://ww2.arb.ca.gov/resources/documents/2026-dam-and-reservoir-petition*; See also Health & Saf. Code, § 38510.

Legislature, through Assembly Bill (AB) 32[2] and subsequent legislation, tasked CARB with adopting regulations requiring the reporting and verification of GHG emissions from sources that contribute most to state emissions.[3] CARB is committed to carrying out these responsibilities and staying at the forefront of the fight against climate change. We thank petitioners for their ideas on tracking GHG emissions from dams and reservoirs and would like to build upon this dialogue moving forward.

I. Summary of Decision and Rationale

CARB denies the Petition to initiate a rulemaking to add dams and reservoirs as reporting entities under the MRR.[4] As an alternative solution to the action requested by the petitioners, CARB intends to work to resolve the petitioners' concerns over accounting for GHG emissions from dams and reservoirs in California's inventories, starting by:

- taking appropriate actions to incorporate greenhouse gas (GHG) accounting for dams and reservoir systems within CARB's Natural and Working Lands (NWL) Carbon Inventory;
- taking initial steps to report dams and reservoir system emissions as Flooded Lands within the wetlands category (3B4) of the Intergovernmental Panel on Climate Change (IPCC) standardized GHG accounting framework;
- reviewing existing research and identifying need for future research to support direct measurement of emissions from dams; and
- convening a meeting to discuss hydropower-related GHG accounting and inviting other state partner agencies to participate in that meeting.

The following summarizes CARB's rationale for this determination:

- The Regulation for MRR is not suitable to account for emissions from dams and reservoirs due, in part, to its design and measurement accuracy requirements. Future research and technological progress towards direct, regular measurement of dam and reservoir system emissions may allow for more rigorous accounting.

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[2] Health & Saf. Code, § 38500 et seq. (Nunez, Stats. 2006, ch. 488).

[3] Health & Saf. Code, § 38530(b)(1).

[4] A state agency may grant or deny the petition in part, and may grant any other relief or take any other action as it may determine to be warranted by the petition and shall notify the petitioner in writing of this action. Gov. Code, § 11340.7(c).

- Insufficient evidence exists that dam and reservoir emissions are a significant source of GHG emissions for the purposes of MRR. The most recent, rigorous studies using models to estimate dam and reservoir emissions document great uncertainty regarding overall levels of emissions due to numerous variables which are difficult to account for. Further scientific research estimating the size of California dam and reservoir system emissions with greater accuracy, completeness, and confidence may provide necessary clarity regarding this threshold issue.
- The NWL Carbon Inventory is designed to report on code 3B, which includes dams and reservoirs (3B4) within the IPCC standardized GHG accounting framework. The NWL Carbon Inventory is logically the best fit among CARB's programs for counting emissions from dam and reservoir systems in California.
- The NWL Carbon Inventory uses the most comprehensive and up-to-date information possible to produce the most accurate accounting possible to inform CARB policy and broader state climate goals, including the AB 1279[5] 2045 carbon neutrality goal. Incorporating dams and reservoirs into future NWL Carbon Inventory updates will help to address the petitioner's goals associated with accounting for emissions from dams and reservoirs.

As described in this response, due to scientific uncertainties, as well as technical, economic, and logistical challenges, CARB is not initiating the requested rulemaking. However, CARB is committed to further dialogue and further study of emissions from dams and reservoirs.

II. Background on AB 32 and the MRR

California is a global leader in developing and implementing actions to mitigate climate change by regulating, incentivizing, and otherwise encouraging actions to reduce GHG emissions. Partners around the world look to California as a model for decarbonization across all economic sectors. Cost-effectively reducing GHG emissions in California not only benefits the State's residents and economy but also supports and encourages other jurisdictions to take similar action to mitigate human-induced climate change. The latest report on climate change from the IPCC shows the world is not doing enough to avoid the worst climate impacts.[6] It is essential that

[5] Health & Saf. Code, § 38562.2 (Muratsuchi, Stats. 2022, ch. 337).

[6] CARB. 2022. 2022 Scoping Plan for Achieving Carbon Neutrality, available at https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp.pdf; IPPC. 2022. Climate Change 2022:

California continue to strengthen its climate mitigation efforts, including by continually researching and better understanding sources of GHG in California and how to measure and reduce them. CARB is the State agency tasked with designing emissions reduction measures to meet California's GHG emissions targets.[7]

A. Global Warming Solutions Act of 2006 (AB 32)

AB 32 requires California to cut GHG emissions to 1990 levels by 2020, to continue and maintain reductions beyond 2020, and to develop a comprehensive strategy to reduce dependence on fossil fuels, stimulate investment in clean and efficient technologies, and improve air quality and public health. AB 32 also requires CARB to adopt regulations for the mandatory reporting of GHG emissions in order to monitor and enforce compliance with CARB's GHG emissions reduction actions, including market-based compliance mechanisms. Specifically, AB 32 directs CARB to adopt regulations that, among other things, "[r]equire the monitoring and annual reporting of greenhouse gas emissions from greenhouse gas emission sources beginning with the sources or categories of sources that contribute the most to statewide emissions."[8] GHG sources are defined as "any source, or category of sources, of greenhouse gas emissions whose emissions are at a level of significance, as determined by the state board, that its participation in the program established under this division will enable the state board to effectively reduce greenhouse gas emissions and monitor compliance with the statewide greenhouse gas emissions limit."[9] CARB's regulations must also "[e]nsure rigorous and consistent accounting of emissions . . . ."[10]

In 2016, the Legislature passed and Governor Brown approved SB 32,[11] which mandates a 40 percent reduction of statewide GHG emissions below 1990 levels by 2030. In 2022, the Legislature passed and Governor Newsom approved AB 1279, which sets statewide goals of achieving carbon neutrality and reducing GHG emissions by 85 percent by 2045.

Mitigation of Climate Change, available at *https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/*.

[7] Health & Saf. Code, § 38501(h).

[8] Health & Saf. Code, § 38530(b)(1).

[9] Health & Saf. Code, § 38505(i).

[10] Health & Saf. Code, § 38530(b)(4).

[11] Health & Saf. Code, § 38566 (Pavley, Stats. 2016, ch. 249).

B. Mandatory Greenhouse Gas Reporting Regulation (MRR)

The purpose of MRR is to establish GHG reporting and verification requirements for operators of certain facilities that directly emit GHGs, suppliers of certain fuels and carbon dioxide, electric power entities, and verifiers of GHG emissions data reports.[12] Of all source categories that are currently regulated under MRR, the total per-category GHG emissions range from approximately 8 million Metric Tons of CO2e (MMCO2e), to approximately 160 MMTCO2e (See Figure 1).

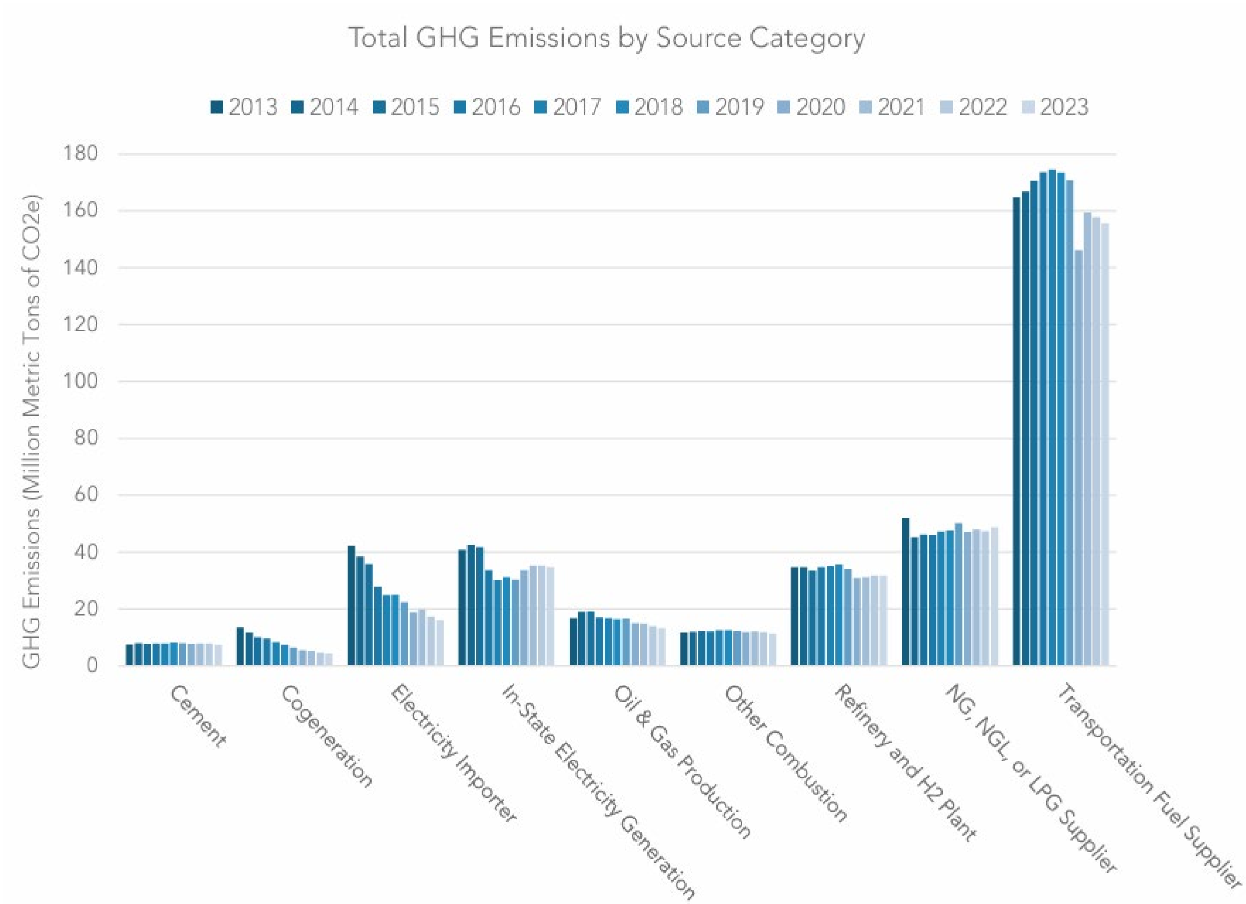

Figure 1 – 2013-2023 Total GHG Emissions by Source Category.[13]

[12] Cal. Code Regs., tit. 17, § 95101.

[13] CARB. 2024. Mandatory Greenhouse Gas Reporting 2023 Emissions Year Frequently Asked Questions, *https://ww2.arb.ca.gov/sites/default/files/classic/cc/reporting/ghg-rep/reported-data/2023mrrfaqs.pdf*.

CARB adopted the MRR in December 2007. The MRR has been amended several times. In December 2010, CARB adopted amendments to harmonize MRR with requirements then in effect for GHG reporting by the U.S. Environmental Protection Agency (U.S. EPA), to support California's Cap-and-Trade Regulation (now known as Cap-and-Invest), and to ensure consistency with the reporting structure that several jurisdictions developed through the Western Climate Initiative. In September 2012, CARB adopted amendments to MRR in order to continue harmonization with U.S. EPA requirements, as well as add conforming definitions to the Cap-and-Invest Regulation and the Cost of Implementation Fee Regulation (COI).

In September 2013, CARB adopted amendments to clarify the reporting requirements, support the Cap-and-Invest Regulation, and other updates. In September 2014, CARB adopted amendments to further clarify the reporting requirements, integrate the COI reporting requirements, and collect additional information to support CARB's various climate change programs, such as the statewide GHG emissions inventory. In July 2017, CARB adopted amendments to support the Cap-and-Invest Regulation and harmonize with the U.S. EPA Clean Power Plan reporting and U.S. EPA rule amendments. CARB adopted amendments in December 2018 to support the Cap-and-Invest Regulation to ensure consistency with the calculation of compliance obligations and to ensure that reported GHG emissions and product data are accurate and complete to support California's GHG reduction programs, including imported electricity emissions from the CAISO Energy Imbalance Market (EIM).

More recently, in May 2026, CARB adopted amendments to align with and support California's Cap-and-Invest Regulation, including allocation and the calculation of compliance obligations, and to ensure that reported GHG emissions and product data are accurate and complete to support California's GHG emissions reduction programs, including the statewide GHG emissions inventory.

III. <u>Scientific Overview of Dam and Reservoir System GHG Emissions</u>

CARB conducted a review of the current state of the science of quantifying and estimating GHG emissions from dam and reservoir systems. This review revealed nuanced but important constraints of current approaches to estimating dam and reservoir system emissions.

GHG emissions from within a reservoir are driven primarily by the aerobic and anaerobic decomposition of organic material. The rate and magnitude of emissions can be affected by the reservoir's size, climate, nutrient and trophic status, and operations. Various methods exist to quantify and scale up field local measurements (known as "upscaling") of GHG emissions from reservoirs; however, the spatial and temporal variability of emissions both within and across reservoirs makes quantification and upscaling a challenging task. Further research and development would be needed to increase the accuracy and quantify the uncertainty of GHG emission estimates from these highly dynamic systems at statewide and regional scales. Estimating these emissions is further complicated by the challenges of distinguishing emissions caused by dams and reservoirs from natural carbon cycling within these systems.

A. CO_2 and CH_4 Emissions from Dams and Reservoirs

In order to respond to petitioners' request, CARB staff conducted a high-level literature and scientific review of GHG emissions from reservoir systems to better understand the measurement and estimation approaches and uncertainties. The following paragraphs summarize CARB staff's initial evaluation.

Within reservoir systems, GHG emissions are produced primarily from the decomposition of organic material. This organic material may come from lacustrine vegetation within the reservoir, terrestrial vegetation neighboring the reservoir, or upstream water sources. As the organic matter decomposes, some of it is released as carbon dioxide (CO_2). CO_2 emissions associated with dams and reservoirs are primarily produced under aerobic conditions. Methane (CH_4), in contrast, is produced through anaerobic decomposition of organic matter under oxygen-depleted conditions. As GHGs are produced, they may be released from the reservoir surface via diffusion (which occurs when concentrations in the water exceed that of the atmosphere), ebullition (which occurs when bubbles rise from the sediment), or plant-mediated transport (which occurs when aquatic plants draw up gases through their aerenchyma). GHGs can also be released downstream of reservoirs via diffusion and degassing (i.e., escape into the atmosphere) as water moves into a river channel or through turbines (Figure 2).

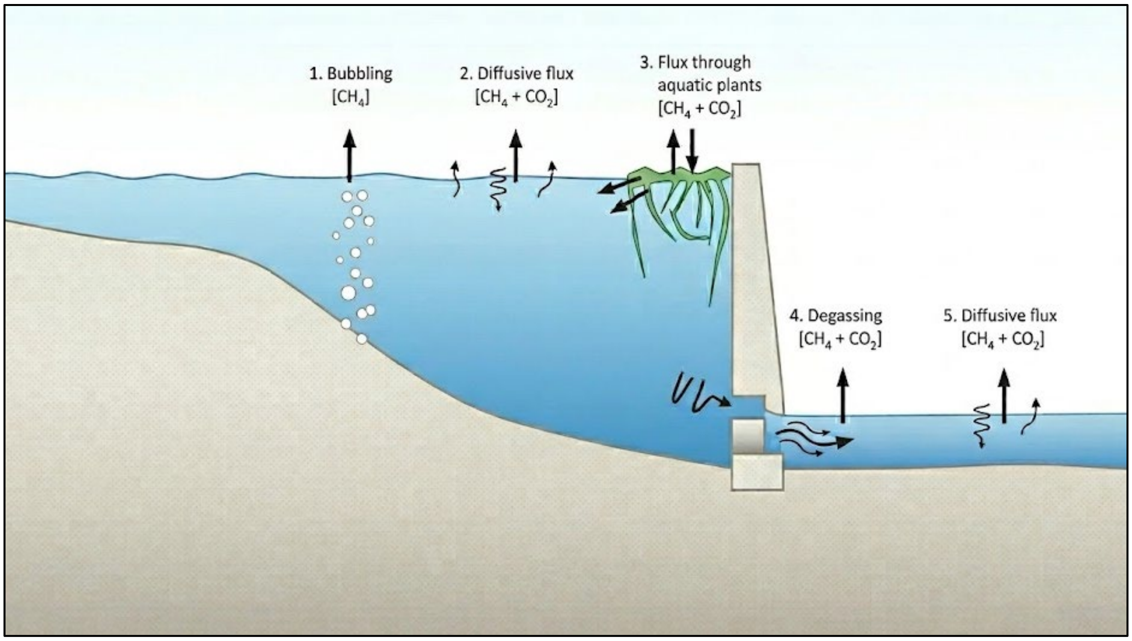

Figure 2 – An illustration of major CO_2 and CH_4 emission pathways in reservoirs. Bubbling = ebullition.

Both within and among reservoirs, the spatial and temporal variability in GHG emissions is substantial (IPCC 2019; Hansen et al. 2023). Within a reservoir, surface emissions have been shown to be sensitive to sediment depth, temperature, seasonal vertical mixing, water drawdown, and the presence of algal blooms, among other factors (Eugster et al. 2011; Maeck et al. 2013; Harrison et al. 2017; Waldo et al. 2021; Jager et al. 2023). In addition to these drivers, the often-dominant process of ebullition inherently adds significant temporal variability to GHG emissions of a reservoir (Beaulieu et al. 2020; Hansen et al. 2023). Across reservoirs, surface emissions have been shown to vary with factors such as reservoir size, climate, nutrient availability, trophic status, and water management (Soumis et al. 2004; Deemer and Holgersen 2021; Jager et al. 2023). The structure of the dam can further influence the amount of CH_4 emitted via degassing, with deeper water carrying more CH_4 with it (Delwich et al. 2022).

B. <u>How Emissions are Empirically Tracked and Measured</u>

Emissions from dam and reservoir systems include reservoir surface emissions, degassing emissions, and downstream emissions. Approaches for measuring each type of emission are described below. A variety of methods exist for aggregating and scaling the several types of dam and reservoir system emissions.

1. Reservoir Surface Emissions

Fluxes of CO_2 and CH_4 associated with reservoirs can be measured using a suite of approaches that vary in their ability to capture spatial and temporal fluctuations, as well as their degree of automation.

The most widely used approaches for measuring reservoir fluxes rely on direct field sampling at discrete points in space and time. For example, rates of CO_2 and CH_4 exchange between reservoir surfaces and the atmosphere are commonly quantified using floating chambers (Seth et al. 2026). This method measures changes in the headspace concentration of CO_2 and CH_4 within a chamber floating on the water surface over a set time period. By measuring total flux within the chamber footprint, it captures the process of diffusion as well as the influence of any bubbles that enter the chamber during deployment. If desired, ebullition can be quantified independently from diffusion by using a submerged, inverted funnel that traps bubbles and delivers the gas to a collection chamber. Diffusive fluxes can also be estimated by comparing CO_2 and CH_4 concentrations measured within the water column with gas concentrations in the atmosphere (using a boundary layer model; Seth et al. 2026). In their traditional form, these methods require manual sampling at regular intervals over a set period of time and are unable to provide long-term, frequent measurements at a high spatial density. As such, they often miss episodic events and fail to capture the large variability in emissions that occur.

Advances in monitoring capabilities have sought to broaden the ability to quantify spatial and temporal trends in GHG fluxes from reservoirs. For instance, researchers have developed automated chamber methods for both CO_2 (Martinsen et al. 2018) and CH_4 (Dietrich et al. 2025) to support longer-term measurements with less manual effort. Dietrich et al. (2025) specifically demonstrated the ability for an automated chamber to collect sub-hourly flux measurements over months without supervision. Other advances have helped improve estimates from specific surface emission pathways. For example, hydroacoustic surveys have been used to detect rising bubbles along survey routes and thus improve estimates of ebullition across a reservoir surface (Maeck et al. 2013; Linkhorst et al. 2021). However, because these surveys are conducted over limited time periods, they may still miss key temporal dynamics associated with this highly variable process. Automated bubble traps, paired with manual bubble gas measurements, have been used to resolve temporal uncertainty in CH_4 ebullition estimates by recording bubble production at fixed locations over time (Varadharajan et al. 2010; Delwiche and Hemond 2017).

In addition to the above advances, researchers have begun trialing a more automated, integrated, and continuous measurement approach in freshwater systems, including reservoirs. This approach relies on the use of eddy covariance flux towers, which measure the net exchange of CO_2 and CH_4 between the atmosphere and the reservoir surface within the tower's upwind flux footprint. While this approach is widely used in terrestrial landscapes, its application to reservoirs and other freshwater bodies on annual timescales is still emerging (Golub et al. 2023; Seth et al. 2026). Flux towers offer an opportunity to measure GHG fluxes continuously over larger areas than chamber-based methods, but the measurements still represent only the portion of the reservoir surface captured within the tower footprint, which can vary with wind direction, atmospheric conditions, and tower placement (Eugster et al. 2011). As a result, eddy covariance can greatly improve temporal resolution, but a single tower is still unlikely to capture the full spatial variability of emissions, especially across larger reservoirs. Additionally, typical eddy covariance systems depend on stationary platforms, requiring placement along the shoreline or on grounded infrastructure. While the use of floating platforms is being explored (Uwe et al. 2020), this limitation creates interference from nearby vegetation or emission sources and prevents sampling in the central reservoir surface.

Satellite-based remote sensing of CO_2 and CH_4 emissions offers another option for measurements, although this approach also has limitations. Indeed, there are numerous existing and planned satellite missions for CO_2 and CH_4 detection (Karambelkar et al. 2025; Seth et al. 2026), and as technologies continue to evolve, they could prove useful in helping to broaden spatial and temporal measurement coverage. However, the utility of satellite observations depends strongly on whether the instrument's detection limit, spatial resolution, and sampling design match the scale and intensity of the emission source itself, and their suitability for capturing reservoir emissions remains to be robustly evaluated. In addition, because satellites measure atmospheric concentrations rather than surface fluxes directly, emission estimates still rely on complex atmospheric modeling and require calibration and validation using field-based measurements. Therefore, satellite-based remote sensing does not replace the need for more traditional measurement approaches.

In summary, the current available approaches to measure reservoir surface emissions lack sufficient confidence and would require more development to lead to accurate emissions estimates from individual dams and reservoirs for the purposes of reporting under the MRR.

2. Degassing and Downstream Emissions

The amount of degassing that occurs as water leaves the dam is commonly estimated using concentration-based methods. Here, CO_2 and CH_4 concentrations are compared in water before and after it passes through dam infrastructure, such as turbines and spillways (Kemenes et al. 2007). The difference in gas concentration between the two locations is then combined with outlet discharge estimates to determine the amount of gas released via degassing. This kind of manual sampling around hydropower infrastructure can be challenging and dangerous; as such, newer automated systems are being researched for their ability to provide real-time concentration data from turbine water with limited maintenance (Deblois et al. 2023). Additional sampling of diffusive fluxes downstream can be measured using floating chambers (Guérin et al. 2006) or dissolved gas concentrations (DelSontro et al. 2016), similar to above.

3. How Dam and Reservoir Emissions are Upscaled

Estimating the net GHG flux from reservoirs requires scaling estimates across space and time. At its simplest, this exercise takes an emissions factor approach whereby an average emission rate is multiplied by the total surface area of a reservoir (or a group of reservoirs). While this approach is simple and straightforward, it masks the substantial variability that exists within and among reservoir systems. A more refined approach uses measured flux data to build empirical models that relate estimates to important drivers (i.e., covariates), such as reservoir size, climate, nutrient availability, and trophic status. These models are then used to predict fluxes at unsampled locations where relevant covariate information exists (Seth et al. 2026). To provide a more mechanistic lens, "semi-empirical" or process-based models can be used to produce estimates for unsampled locations by combining measured data with simplified representations of the processes responsible for moderating GHG dynamics (Delwiche et al. 2022; Seth et al. 2026).

The most widely used modeling tool for upscaling reservoir GHG emissions is the GHG Reservoir Tool (G-res Tool). G-res relies on a series of empirical models developed from global datasets to estimate the net GHG footprint of a reservoir over its lifetime (Prairie et al. 2017). While this tool is a considerable advancement in the application of reservoir modeling to real-world needs (Karambelkar et al. 2025; Seth et al. 2026), its approach remains limited, and its predictions imprecise (Karambelkar et al. 2025; Pilla et al. 2025).

In conclusion, accurately measuring emissions and then creating upscaled emissions estimates from dams and reservoirs, even when using net flux methods, remains a challenge.

IV. Existing Estimation and Reporting Methodologies for Dam and Reservoir System Emissions

The IPCC provides a methodology for estimating and reporting dam and reservoir system emissions consistent with currently available science. This existing framework provides a potential avenue for CARB to estimate and track California dam and reservoir emissions, and has previously been used by the U.S. EPA to estimate dam and reservoir emissions in California as described below.

A. IPCC Reporting Guidelines for Dams and Reservoir Systems

The IPCC standardized GHG accounting framework enables governing entities to produce robust and comparable estimates of net GHG emissions within their jurisdictional boundaries. This framework is used by countries worldwide to compile their national GHG inventories under the United Nations Framework Convention on Climate Change (UNFCCC). The guidance is organized by sector and covers all major GHGs, including CO_2, methane (CH_4), nitrous oxide (N_2O), and other short-lived climate pollutants.

Under the IPCC GHG accounting framework, dams and reservoirs are reported as Flooded Lands within the wetlands category (3B4) of the agriculture, forestry, and other land use (AFOLU) sector (Figures 3 & 4). Thus, this is how it is reported for the US GHG Inventory (EPA 2024) as well as other governing entities such as Canada (ECCC 2025).

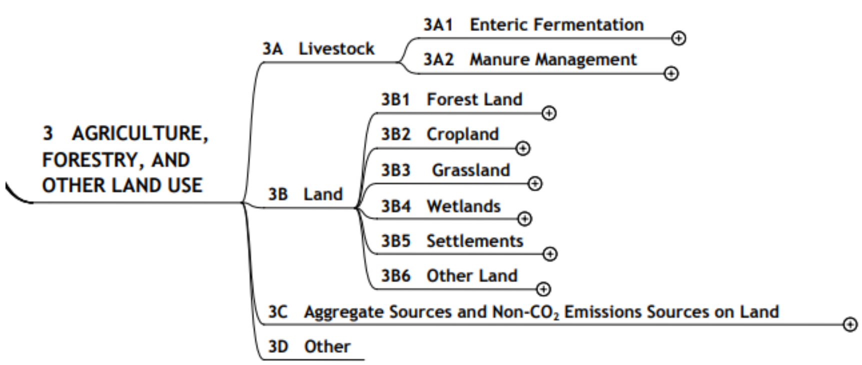

Figure 3 - Main categories of emissions by sources and removals by sinks within the AFOLU sector (IPCC 2006b). Following the IPCC framework, dams and reservoirs are quantified within the Wetlands category (3B4). CARB's NWL Carbon Inventory covers all of 3B, including 3B4.

Figure 4 - This subset of the IPCC AFOLU reporting structure diagram shows the Flooded Lands category (dams and reservoirs) within the broader Wetlands reporting category (IPCC 2006c).

The IPCC provides guidance on how to quantify CO_2 and CH_4 emissions from dams and reservoirs within the wetlands chapter of the 2019 Refinement to the 2006 IPCC Guidelines (IPCC 2019). For CO_2, the guidance focuses on estimating emissions that occur when the land is first flooded, with CO_2 emissions from the surrounding unflooded catchment accounted for in other land categories. For CH_4, the guidance provides methods for estimating emissions across the major reservoir pathways, including diffusive, ebullitive, and downstream (degassing and diffusive) emissions.

Because selecting an appropriate upscaling approach depends on several factors, including data availability and technical expertise, the IPCC provides a tiered framework that allows national and subnational entities to generate scaled estimates in a way that is responsive to these dependencies. Tier 1 methods rely on default emission factors and relatively simple “activity” data, making them useful where information is limited. For reservoirs, the IPCC Tier 1 methods provide guidance on using emission factors that were developed by the Greenhouse Gas Reservoir (G-res) model (Prairie et al. 2017) and grouped into IPCC climate zone. Adjustment factors for nutrient status and productivity of reservoirs are provided to modify these default factors, if desired. Tier 2 methods provide guidance on generating region-specific emission factors that can take into account reservoir withdrawal depth, mean annual chlorophyll *a* concentration, trophic status, and additional contextual information. Tier 3 methods provide guidance on using process-based or empirical models and measurement campaigns to tailor estimates further.

Additionally, methods supported by the IPCC are for broad inventory estimation at the national or jurisdictional scale (e.g., state scale), and generally are not designed to maximize accuracy for any individual facility or reservoir to the same level of confidence as would be required under MRR.

B. Previous estimate of California emissions using the IPCC Guidelines

A 2024 US EPA report, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2022 (“US GHG Inventory”), provides emission estimates for reservoirs following the Tier 1 methodology in the 2019 Refinement to the 2006 IPCC Guidelines (IPCC 2019) described above.

The 2024 U.S. GHG Inventory report estimates that California reservoirs emitted 1.3 MMT CO_2e from surface and downstream pathways in 2022 (EPA 2024). The petitioner's estimates were considerably larger, at 5.3 MMT CO_2e. For context, other wetland types across California emitted a combined 0.44 MMT CO_2e in 2022 (CARB 2025), and wildfire in California emitted an average of 23.8 MMT CO_2e per year between 2001-2022. In that same timeframe, the combustion and decay of harvested wood products emitted an average of 14.6 MMT CO_2e per year (CARB 2025).

V. Challenges with Accurately Quantifying Dam and Reservoir System Emissions

Although estimates exist for California dam and reservoir system emissions, accurately and rigorously quantifying these emissions through direction measurement remains a challenge due to limitations of presently available measurement techniques, numerous sources of uncertainty in emissions from individual reservoirs, and difficulties scaling measurements to a statewide level.

A. Sources of Uncertainty in Measuring Dam and Reservoir System GHG Emissions

Numerous sources of uncertainty exist when quantifying reservoir GHG emissions, even among the most current and widely used methodologies. For instance, pronounced spatial and temporal patterns in reservoir GHG fluxes, paired with insufficient sampling campaigns, introduce large uncertainties into emission rate estimates that propagate during the upscaling process (Beaulieu et al. 2016; Pilla et al. 2025). This includes bias introduced from the predominance of daytime measurements, which fail to account for diel variability (Sø et al. 2023; Naslund et al. 2024). It also includes bias introduced when flux estimates are extrapolated from a non-representative subset of reservoirs often chosen for convenience (Beaulieu et al. 2020). Additional uncertainty is introduced with the covariate estimates required for upscaling. As an example, Delwiche et al. (2022) showed certain input parameters for the ResME model contained prediction intervals that ranged up to an order of magnitude. Finally, fluctuations in reservoir area are an important source of uncertainty in emission estimates as well (IPCC 2019; EPA 2024; Hansen et al. 2025). These and other uncertainties combine to make reservoir GHG budgets extremely difficult to constrain.

The high uncertainty associated with reservoir estimates can be seen across scales. For global Tier 1 estimates, the IPCC includes 95% confidence intervals (CI) associated with emission factors in different climates, which range from 15-20% of the modeled mean for CH_4 surface emissions and 190% of the median for downstream CH_4 emissions (IPCC 2019). In addition, a recent global analysis confirmed that degassing produces the largest but also the most uncertain flux using the G-res model, with global estimates ranging five-fold (95% CI from 227-1,261 MMT $CO_2e\ y^{-1}$) (Harrison et al. 2021). When considering different surface flux pathways within a single reservoir in Ohio, Beaulieu et al. (2016) reported 95% CI ranges for diffusive and ebullitive CH_4 fluxes as 32% and 58% of their respective means, although the magnitude of uncertainty may differ in California reservoirs. These examples are just a few of many in a growing body of literature that aim to highlight and mitigate the uncertainty of reservoir estimates (Karambelkar et al. 2025; Seth et al. 2026).

To reduce uncertainties, robust, statistically valid sampling campaigns that consider variability within and among reservoirs are required. These campaigns must include enough sampling stations and sampling periods per reservoir as well as enough reservoirs per area (IPCC 2019). In addition, obtaining accurate measurement of covariates such as dissolved organic carbon and chlorophyll *a* alongside GHG flux measurements are required to provide critical data needed to reduce uncertainty during upscaling (Deemer and Holgerson 2021). In California specifically, multiple streams of California-specific field data (including GHG emissions and co-variates) must be combined with management information from reservoirs and remote sensing frameworks to constrain uncertainty statewide. These campaigns require additional data collection through existing procedures, as well as the development and application of novel or emerging methodologies described above that work for California systems.

B. Challenges Associated with Measurement and Upscaling of Dam and Reservoir System GHG Emissions

Fundamental technological barriers stand in the way of collecting complete and accurate GHG emissions data from reservoirs across California, as requested by the petitioners. For a single operation, considerable time and effort would be required for reporting entities to conduct field sampling and produce accurate reservoir-wide GHG budgets. In one estimate using standard monitoring approaches (IHA 2010), an average of 4 sampling campaigns covering 20-30 sampling stations within a reservoir would be required to achieve 10% precision in the mean. For smaller reservoirs, the number of sampling stations required may be lower, but at least half a dozen locations would still be needed (Naslund et al. 2024). To provide context for the amount of staff time this would require, it took Bevelhimer et al. (2016) 2-3 days within a given reservoir to measure diffuse emissions from six sites, ebullition from two sites, and degassing using concentration-based measurements from the reservoir and downstream tailwater. This did not include pre-sampling preparation or post-sampling analysis.

In addition to the time required for field sampling, reservoir GHG monitoring depends on specialized, often costly equipment, instrumentation, and technical expertise. For instance, common floating chamber methods require either access to a laboratory for gas analysis or connection to an in-situ gas analyzer, which can cost on the order of ~$40,000. Newer autonomous floating chambers can reduce costs considerably (one unit is approximately ~$1,000) (Dietrich et al. 2025), but they still require specialized expertise to assemble, deploy, operate, and analyze. In addition, eddy covariance flux towers cost between $100,000-$150,000 to procure and install, and then another ~$100,000 per year to maintain. These estimates are likely on the low side for reservoir-based flux towers, given additional investments would be needed to build floating structures and outfit towers with additional equipment to correct estimates if those structures are not stable. In addition, deploying and maintaining flux towers requires considerable specialized expertise, particularly over water, where methods and infrastructure are still being tested and refined.

Practical barriers also arise when upscaling site-level field measurements. To generate GHG budgets for a single reservoir, measurements from individual stations must be upscaled to represent the full water body, requiring staff time and scientific ability to deploy any number of the approaches described in the *Upscaling* section, above. With nearly 1,500 reservoirs distributed across the state, estimating reservoir emissions across California collectively requires technical expertise with strong scientific understanding to leverage emerging field data, management data, and remote sensing products to go beyond Tier 1 estimates.

VI. Rationale for Decision

Petitioners urge CARB to include dams and reservoirs—both those that generate hydropower and those that do not—as reporting entities that must report their GHG emissions under MRR. At present, CARB does not believe that such emissions are capable of the rigorous quantification AB 32 directs MRR to require, nor that there is sufficient information to conclude that dam and reservoir system emissions are a significant source of emissions under MRR.

A. Rigorous and Consistent Accounting of Dam and Reservoir System Emissions Is Not Yet Possible

Petitioners suggest that including dam and reservoir systems in MRR is proper because including these emissions would "fit well within the MRR's current purpose and structure" because they are "anthropogenic processes that generate point source-type emissions similar to the other facilities and source categories currently required to report emissions under the MRR."[14] However, the "fit" between dam and reservoir system emissions and MRR is in tension with AB 32's direction that CARB create and implement MRR to "ensure rigorous and consistent accounting of emissions."

Unlike sources regulated under MRR, emissions from dam and reservoir systems, at present, are not capable of the rigorous and consistent accounting required for MRR. Specifically: 1) technology sufficient to accurately and cost-effectively measure dam and reservoir system emissions is not yet available to allow for measurement at scale in accordance with the rigorous standards required by the MRR; and 2) understanding dam and reservoir systems' contribution to climate change requires using ecosystem modeling and construction of counterfactual assumptions which introduce levels of uncertainty that MRR has not been designed to accommodate.

1. *Current Technical, Economic, and Logistical Limitations Preclude Direct, Continuous Measurement of Dam and Reservoir System Emissions in Accordance with MRR's Accuracy Standards*

AB 32 directs CARB to ensure its regulations AB 32 to those for which "ensure rigorous and consistent accounting of emissions." Therefore, MRR has historically required rigorous and consistent accounting and verification of emissions. Sources covered by MRR to date primarily consist of activities related to fuel combustion, chemical conversion of feedstocks, and/or vented emissions where inputs and/or resulting stack emissions can be measured with devices demonstrated to be accurate within the +/- 5% accuracy standards specified in MRR—a standard that has existed since MRR's adoption in 2007. In contrast, dams and reservoirs are fugitive emissions sources which produce diffuse, spatially and temporally variable emissions. Fugitive emission sources are not typically incorporated into MRR reporting because of the

[14] Petition at 1.

inability to measure them at the accuracy specifications required by the MRR program.[15]

Emissions sources at facilities subject to MRR must meet the +/-5% measurement accuracy requirements, pursuant to section 95103(k), title 17, California Code of Regulations, based on measured fuel parameters such as mass and volume and fuel characteristic data. This standard is based on industry-accepted quantification methods and relies on clear emissions boundaries for accurate and consistent measurement (2007 MRR ISOR). As discussed in the Sources of Uncertainty section above, there are myriad factors contributing to the significant uncertainty in quantifying emissions from dams and reservoirs that remain active areas of research. While some devices utilized in measuring methane emissions in dams and reservoirs may meet the accuracy requirement of MRR, the factors that drive total reservoir emissions (some of which are unknown) vary significantly across reservoirs in the state, leading to high spatial and temporal variability in emissions. Uncertainties in quantification methodologies to accurately capture this variability extend beyond the measuring device and result in overall emissions estimates that would not meet the MRR accuracy requirement.

The measurement efforts discussed in the *How Emissions are Empirically Tracked and Measured* section above describe the range of methodologies that have been used in these systems. Widely accepted and standardized methods for quantifying emissions from dams and reservoirs do not exist currently. Satellite-based measurements of emissions, as discussed in the *How Emissions are Empirically Tracked and Measured* section above, remain uncertain and have not been employed by other sectors included in the MRR for similar reasons.

A combination of widespread, continuous sampling campaigns and deployment of direct measurement devices, described above, could theoretically provide accurate measurements of some types of dam and reservoir system emissions at scale. However, the cost and logistics of such an effort have not been studied; without even preliminary research on this topic, determining with reasonable accuracy the economic impact of mandatory reporting of dam and reservoir system emissions—an

[15] MRR reporting includes a limited number of small fugitive sources at facilities in the refining and oil and gas production sectors that are otherwise required to report emissions from fuel combustion, consumption and venting processes. Fugitive emissions from the transmission and distribution of natural gas by pipelines are reported by natural gas suppliers.

administrative requirement of the rulemaking process—would be very difficult, if not impossible.

The final issue with incorporating dam and reservoir system emissions into MRR is verification. A key component of the MRR is the third-party verification program. For verifiers to reach reasonable assurance of the accuracy of the reported emissions, as required by the MRR, they must trace emission quantification to a reliable data source that they are confident in and for which the uncertainty is known. The body of science for dam and reservoir emissions discussed in the sections above shows that quantification methods continue to require research and development to address the numerous sources of uncertainty. Additionally, the physical boundaries for emission sources may change over time as reservoir conditions fluctuate, creating inconsistencies from a verification perspective. Without a more established body of science, verifiers may be challenged to meet the reasonable assurance threshold.

2. *Calculating Dam and Reservoir System Net Emissions Without Direct, Regular Measurement Would Require Use of Modeling Which MRR Does Not Accommodate*

Industrial and transportation-related emissions from the combustion and use of fossil fuels and other organic compounds—a primary focus of MRR—have the distinct advantage of being readily measured because they result from the release of CO_2 from extraction and combustion of fossil fuels. Fossil fuel combustion transfers carbon from long-term storage in geologic reservoirs into the atmosphere as an effectively permanent addition on human timescales.

In contrast, CH_4 and CO_2 emissions from dams and reservoirs redistribute carbon already cycling through the land-atmosphere system. These emissions originate in organic material that is part of a faster, more dynamic cycle between the atmosphere, plants, soil, and water, in which carbon emitted in one year can be reabsorbed by ongoing growth across the landscape in the same or subsequent years. Understanding the contribution of one molecule of methane emitted from a dam or reservoir to climate change is not as simple as detecting when and where the molecule was emitted—it requires a comprehensive understanding of the methane molecule's life cycle prior to emission into the atmosphere.

The ecosystem modeling described requires intensive research and development and necessarily introduces uncertainty into any calculation of carbon intensity, which makes rigorous measurement and accurate accounting challenging. MRR, which as noted previously requires measurement techniques to be accurate within +/-5%, has not been designed to allow for the inclusion of sources which require ecosystem modeling and counterfactual scenarios to accurately quantify.

B. Insufficient Evidence Exists that Dam and Reservoir System Emissions in California Are a Significant Source of Emissions for Purposes of MRR

Petitioners assert that dam and reservoir systems are a "significant source of GHG emissions" that are "going unreported and unconsidered" presently, and thus CARB "must take action to revise its reporting regulations" to include dam and reservoir system emissions.[16] However, emissions for reservoirs and dams (for the over 1,300 that exist in the state) are far lower, and thus less significant, than the source categories that are currently regulated under MRR. The lowest-emitting MRR source category, cement plants (of which there are 7 facilities in the state), emits nearly double the GHG emissions as the most generous estimate of dam and reservoirs, and other MRR source categories emit up to 160 MMTCO2e (as of 2023 data; see Figure 1). Based on the estimates CARB evaluated, ranging from approximately 1 to 5 MMTCO2e, CARB is unable to reach the conclusion that dam and reservoir systems are a significant source of emissions relative to other MRR source categories, necessitating regulation under MRR.

AB 32 directs CARB to regulate sources and categories of sources of GHGs the emissions of which "are at a level of significance, as determined by [CARB], that [their] participation in [CARB's AB 32 programs) will enable [CARB] to effectively reduce greenhouse gas emissions and monitor compliance with the statewide greenhouse gas emissions limit." Additionally, AB 32 directs CARB to begin focusing MRR on those sources and source categories which "contribute the most to statewide emissions."[17]

As discussed above, based on CARB's review of scientific literature, including sources provided by petitioners, CARB is not able to determine whether dam and reservoir system emissions constitute a significant source of GHG emissions relative to other MRR source categories. Even the most recent, rigorous studies estimating dam and reservoir emissions document great uncertainty regarding overall levels of emissions due to numerous variables which are difficult to account for, such as daily and seasonal variability of fluxes, challenges with identifying and sampling a representative subset of reservoirs for purposes of scaling emissions estimates, and

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[16] Petition at 27.

[17] Health & Saf. Code, § 38530.

reliance of degassing estimates on multiple, unsettled assumptions. Further scientific research estimating the size of California dam and reservoir system emissions with greater accuracy, completeness, and confidence may provide necessary clarity regarding the threshold issue of whether California dam and reservoir system emissions represent a major source of emissions in California. Although this is an active area of research, technological advancements in measuring and quantifying dam and reservoir system emissions—discussed above and in further detail below—may be needed for such research to occur.

VII. The NWL Carbon Inventory is the Appropriate Tool to Track Dam and Reservoir System Emissions in California

The NWL Carbon Inventory is the State's official inventory for quantifying the contribution of NWL (IPCC category 3B) toward carbon neutrality. The primary objective of the NWL Carbon Inventory is to provide an estimate of organic carbon stored in the State's land base, serving as a tool to support California's climate goals. It monitors carbon stocks across California through time in a way that captures the impacts of climate, wildfires, land use change, and land management activities. Following IPCC guidance, the NWL Carbon Inventory also assesses GHG fluxes from wetlands. All landscapes are estimated within the inventory, even ones highly modified by human activity, including urban areas, croplands, and managed wetlands. The emissions associated with dams and reservoir systems are well suited to being counted within the NWL Carbon Inventory, which counts carbon and emissions across the entire landscape of California.

CARB's NWL Carbon Inventory addresses IPCC code 3B within the AFOLU sector (Figures 3 & 4). As part of its objective, the NWL Carbon Inventory provides a quantitative estimate of GHG fluxes from, and organic carbon stored in, wetlands statewide (Figure 5).

To date, dams and reservoirs have not been included in the NWL Carbon Inventory due to a combination of data, methodological, and resource limitations. However, future iterations could explore Tier 1, 2, or 3 approaches to incorporate GHG flux estimates for this Flooded Lands category. The NWL Carbon Inventory is designed to be responsive to advances in science and technology and does not require regulatory updates to incorporate methodological changes. As such, it offers a nimble, flexible framework for landscapes such as reservoirs, where uncertainty remains high but methods, data availability, and scientific understanding are rapidly evolving.

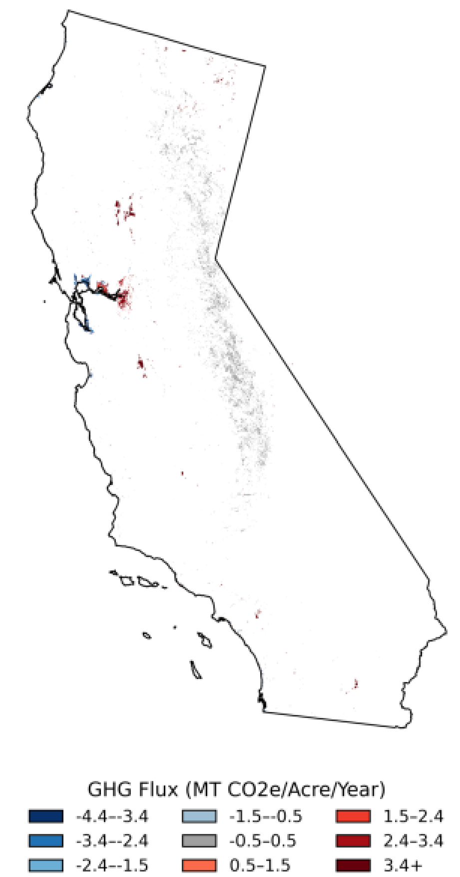

Figure 5 - Greenhouse gas flux from California's wetlands in 2022. Values are expressed in metric tons of CO_2e/acre/year. CO2e includes both CO_2 and CH_4 emissions (CARB 2025).

Methodologically, the NWL Carbon Inventory combines field measurements, emission factors, remote sensing data products, and models to produce its estimates. Although land-sector entities are not currently required to report actions or emissions to CARB for purposes of the NWL Carbon Inventory, it uses the most comprehensive and up-to-date information possible to produce the most accurate accounting possible. Going forward, planned efforts to maintain and improve the inventory include expanding the quality and coverage of field-based observations, leveraging state-of-the-art remote sensing technologies, and integrating more detailed data on disturbance and land management into modeling efforts. This all-of-the-above measuring and modeling approach is a logical fit for dam and reservoir system emissions, which as discussed above, cannot presently be directly measured at scale.

The NWL Carbon Inventory complements CARB's AB 32 GHG Inventory. The AB 32 GHG Inventory addresses GHG emissions from other select categories of agriculture (IPCC code 3A & 3C), as well as from the industry, transportation, electric power, commercial and residential, and recycling and waste sectors. Together, these inventories provide a more complete tracking of the state's GHG emissions and removals over time and work together to provide transparency on the State's progress toward carbon neutrality (Figure 6).

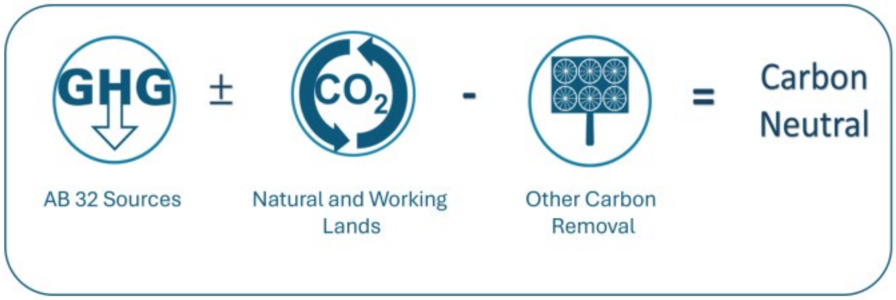

Figure 6 - Reaching carbon neutrality by 2045 requires reducing statewide GHG emissions from AB 32 sources by 85% below 1990 levels, accounting for natural and working lands, and balancing any remaining emissions through carbon removal technologies. CARB's AB 32 GHG Inventory and NWL Carbon Inventory set the foundation for tracking progress toward California's carbon neutrality goal.

As discussed above, estimates of emissions from California's reservoirs range greatly, from 1.3 MMT CO_2e as reported by the U.S. GHG Inventory, and 5.3 MMT CO_2e, as suggested by the petitioners. Given this range of estimates and the uncertainty inherent in current approaches to estimating reservoir emissions, CARB staff are committing to continue to evaluate and improve estimates of California's reservoir emissions in a future inventory release, following incorporation of dam and reservoir system emissions into the NWL.

The NWL Carbon Inventory is CARB's official inventory to track GHG fluxes associated with wetlands, including Flooded Lands under the IPCC framework. While Flooded Lands are not currently included in the inventory, it is designed to produce spatially explicit results that can be aggregated to provide GHG flux estimates for wetland categories statewide and by region (CARB 2025). Results are disaggregated by year, county, air district, ownership, and region, and made available to the public. The NWL Carbon Inventory employs an all-of-the-above approach to quantification, utilizing systems-level modeling and remote sensing techniques that estimating dam and reservoir system emissions at scale presently requires. Including Flooded Lands in future iterations of the NWL Carbon Inventory would be an effective way to raise awareness of dams and reservoirs' GHG emissions and help ensure robust access to accurate and timely GHG estimates.

Furthermore, the NWL Carbon Inventory is a tool to provide transparency on progress towards the State's climate goals and can be leveraged as appropriate to support the maintenance or development of science-based policies. Information from the NWL Carbon Inventory is used to evaluate progress towards California's climate and carbon neutrality targets, including California goal of achieving carbon neutrality by 2045. The NWL Carbon Inventory estimates CH_4 emissions from wetlands following the standardized IPCC framework, which is designed to provide robust and comparable inventory estimates across jurisdictional boundaries. Including Flooded Lands following the standardized IPPC framework in future iterations of the NWL Carbon Inventory will help ensure the State is accounting for emissions of CH_4 from dams and reservoirs.

VIII. Determination and Conclusion

After careful consideration of the Petition for rulemaking, the relevant law, and the current context of ongoing policy development and anticipated implementation activity, CARB denies petitioners' Petition for rulemaking but grants other relief, pursuant to Government Code section 11340.7,[18] which provides that CARB "may grant or deny the Petition in part and may grant any other relief or take any other action it may determine to be warranted by the petition."[19]

Specifically, CARB is:

1. Denying the Petition by declining to initiate a rulemaking to include dams and reservoirs in CARB's MRR regulation at this time.
2. Granting other relief by affirming that CARB will continue to engage with petitioners, other stakeholders, and partner agencies on tracking dam and reservoir system emissions in California raised in the petition; namely, through consideration and implementation of adding Flooded Lands—which include dams and reservoir-produced GHG emissions—to the inventory of Natural and Working Lands in California. In addition, CARB will review existing research and

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[18] CARB may delegate any duty it deems appropriate to its Executive Officer (Health & Saf. Code, § 39515(a)). CARB is conclusively presumed to have delegated any of its powers to the Executive Officer unless it has expressly reserved that power to itself (Health & Saf. Code, § 39516). CARB has not reserved the power to act on rulemaking petitions and it is, therefore, appropriate for the Executive Officer to act on this petition pursuant to this delegated authority.

[19] Gov. Code, § 11340.7 provides that an agency addressing a petition shall "identify the agency, the party submitting the petition, the provisions of the California Code of Regulations requested to be affected, reference to authority to take the action requested, the reasons supporting the agency determination, an agency contact person, and the right of interested persons to obtain a copy of the petition from the agency." This response fulfills those requirements.

identify needs for future research to support direct measurement of emissions from dams. Lastly, CARB will convene a meeting to discuss hydropower-related GHG accounting and invite other state partner agencies to participate in that meeting.

The record upon which this decision is based includes the Petition and its exhibits, this letter, and the materials referenced herein. While CARB is denying the Petition to initiate rulemaking, CARB appreciates and welcomes petitioners' continued engagement and information sharing within these ongoing public processes to improve our programs and the achievement of our shared important policy goals.

In accordance with Government Code section 11340.7, subdivision (d), a copy of this letter is being transmitted to the Office of Administrative Law for publication in the California Regulatory Notice Register. The agency contact persons in this matter are Alex Mesher, Attorney, available at *alexander.mesher@arb.ca.gov* and Aria Soeprono, Attorney, available at *aria.soeprono@arb.ca.gov*. Interested parties may obtain a copy of the Petition upon request to Roberta Ruch, available at 279-208-7781. Upon request, physical copies may be obtained from 1001 I Street, Sacramento, California, 95814.

Sincerely,

Steven S. Cliff, Ph.D., Executive Officer

cc: (via email only)

Lauren Sanchez, Chair

California Air Resources Board Honorable Board Members

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