

**California Air Resources Board**

**Quantification Methodology for the  
California Department of Fish and Wildlife  
Wetlands Restoration for Greenhouse Gas Reduction  
Grant Program**

**California Climate Investments  
Greenhouse Gas Reduction Fund**



**FINAL  
June 15, 2018**

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## Section A. Introduction

California Climate Investments is a statewide initiative that puts billions of Cap-and-Trade dollars to work facilitating greenhouse gas (GHG) emission reductions; strengthening the economy; improving public health and the environment; and providing benefits to residents of disadvantaged communities, low-income communities, and low-income households, collectively referred to as “priority populations.” Where applicable and to the extent feasible, California Climate Investments must maximize economic, environmental, and public health co-benefits to the State.

The California Air Resources Board (CARB) is responsible for providing guidance on estimating the net GHG benefit and co-benefits from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). This guidance includes quantification methodologies, co-benefit assessment methodologies, and benefit calculator tools. CARB develops these methodologies and tools based on the project types eligible for funding by each administering agency, as reflected in the program expenditure records available at:

<https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/expenditurerecords.htm>.

For the California Department of Fish and Wildlife’s (CDFW) Wetlands Restoration for Greenhouse Gas Reduction Program, CARB staff developed this Wetlands Restoration for Greenhouse Gas Reduction Program Quantification Methodology and Benefits Calculator Tool to provide guidance for estimating the net GHG benefit and select co-benefits of each proposed project type (Section B), provide instructions for documenting and supporting the estimate (Section C), and outline the process for tracking and reporting GHG and other benefits once a project is funded (Section D).

This methodology uses calculations to estimate carbon sequestration in restored wetlands, changes in soil organic matter decomposition due to land use change, avoided nitrous oxide emissions due to land use change, and methane production in rewetted soil. Projects will report the project GHG benefits estimated using this methodology as well as the total project GHG benefits per total dollar of GGRF funds requested.

In an effort to enhance the analysis, provide greater transparency, and assist in project-level reporting, CARB has included an additional output tab for select co-benefits and key variables. Key variables are project characteristics that contribute to a project’s net GHG benefit and signal an additional benefit (e.g., renewable energy generated, trees planted).

Using largely the same inputs required to estimate net GHG benefit, the Wetlands Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool estimates the following co-benefits and key variables from Wetlands Restoration for Greenhouse Gas Reduction Program projects:

- Land Restored (in acres)

Additional co-benefits for which CARB assessment methodologies were not incorporated into the Benefits Calculator Tool may also be applicable to the project. Applicants should consult the Wetlands Restoration for Greenhouse Gas Reduction Program Proposal Solicitation Notice, solicitation materials, and agreements to ensure they are meeting Wetlands Restoration for Greenhouse Gas Reduction Program requirements.

## Wetlands Restoration for Greenhouse Gas Reduction Program Project Types

The Wetlands Restoration for Greenhouse Gas Reduction Program achieves a net GHG benefit by decreasing rates of soil organic matter loss, increasing wetland carbon sequestration, and avoiding GHG emissions created by agricultural and other land uses. CDFW developed three project types that meet the objectives of the Wetlands Restoration for Greenhouse Gas Reduction Program and for which there are methods to quantify a net GHG benefit.<sup>i</sup> Each project requesting GGRF funding must include at least one of the following project components for FY 2017-18:

- Sacramento-San Joaquin Delta Wetlands Restoration
- Coastal Tidal Wetlands Restoration; and
- Mountain Meadows Restoration.

Section B of this Quantification Methodology details the methods to use based on the project type(s) proposed.

## Methodology Development

CARB and CDFW developed this Quantification Methodology consistent with the guiding implementation principles of California Climate Investments, including ensuring transparency and accountability.<sup>ii</sup> CARB and CDFW developed this Quantification Methodology to be used to estimate the outcomes of proposed projects, inform project selection, and track results of funded projects. The implementing principles ensure that the methodology would:

- Apply at the project-level;
- Provide uniform methods to be applied statewide, and be accessible by all applicants;
- Use existing and proven methods;
- Use project-level data, where available and appropriate; and
- Result in net GHG benefit estimates that are conservative and supported by empirical literature.

CARB assessed peer-reviewed literature and tools and consulted with experts, as needed, to determine methods appropriate for the Wetland Restoration for Greenhouse Gas Reduction Program project types. CARB also consulted with CDFW to determine project-level inputs available. The methods were developed to provide estimates that are as accurate as possible with data readily available at the project level.

CARB released the Draft Quantification Methodology and Draft Calculator Tool for public comment in May 2018. This Final Quantification Methodology and accompanying Calculator Tool have been updated to address public comments, where appropriate, and for consistency with updates to the Wetland Restoration for Greenhouse Gas Reduction Program Proposal Solicitation Notice (PSN).

In addition, the University of California, Berkeley, in collaboration with CARB, developed assessment methodologies for a variety of co-benefits such as providing cost savings, lessening the impacts and effects of climate change, and reducing the incidence of asthma/respiratory disease. As they become available, co-benefit assessment methodologies are posted at: [www.arb.ca.gov/cci-cobenefits](http://www.arb.ca.gov/cci-cobenefits).

## Tools

This Wetland Restoration for Greenhouse Gas Reduction Program Quantification Methodology and accompanying Benefits Calculator Tool rely on CARB-developed emission factors. CARB has established a single repository for emission factors used in quantification methodologies, referred to as the California Climate Investments Quantification Methodology Emission Factor Database (Database).<sup>iii</sup> The Database Documentation explains how emission factors used in CARB quantification methodologies are developed and updated.

Applicants must use this Quantification Methodology, in conjunction with the accompanying Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool, to estimate the net GHG benefit and co-benefits of the proposed project. The Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool can be downloaded from:

[www.arb.ca.gov/cci-resources](http://www.arb.ca.gov/cci-resources).

## Updates

CARB staff periodically review each quantification methodology to evaluate its effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified. CARB updated the Wetland Restoration for Greenhouse Gas Reduction Program Quantification Methodology from the previous version<sup>iv</sup> to enhance the analysis and provide additional clarity. The changes include:

- More prescriptive methods for quantifying GHG emissions benefits created by wetland restoration projects, using guidance from the Intergovernmental Panel on Climate Change (IPCC), United States Department of Agriculture (USDA), the American Carbon Registry (ACR), and peer-reviewed published literature.
- The creation of a Calculator Tool that assists in estimating GHG benefits created by wetland restoration projects.
- Addition of new output tab in the Benefits Calculator Tool that summarizes select co-benefits and key variables using largely the same inputs used to estimate the net GHG benefit.

## Program Assistance

CARB and CDFW staff will review the quantification portions of the Wetlands Restoration for Greenhouse Gas Reduction Program project applications to ensure that the methods described in this document were properly applied to estimate the net GHG benefit and co-benefits for the proposed project. Applicants should use the following resources for additional questions and comments:

- Questions on this document should be sent to: [GGRFProgram@arb.ca.gov](mailto:GGRFProgram@arb.ca.gov).
- For more information on CARB's efforts to support implementation of GGRF investments, see: <https://www.arb.ca.gov/auctionproceeds>.
- Questions pertaining to the Wetland Restoration for Greenhouse Gas Reduction Program should be sent to [WatershedGrants@wildlife.ca.gov](mailto:WatershedGrants@wildlife.ca.gov).

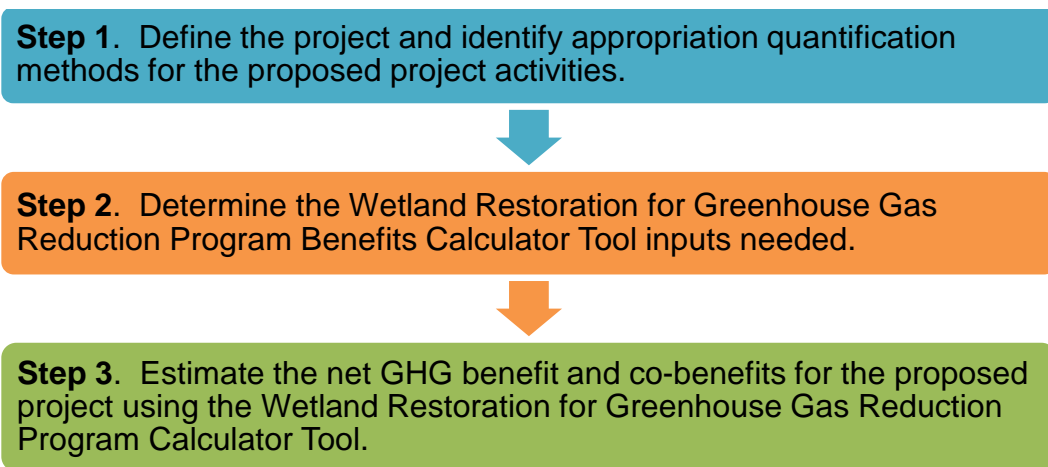
## Section B. Quantification Methodology

### Overview

Applicants will follow the steps outlined in Figure 1 to estimate the net GHG benefit and co-benefits from the proposed project. Detailed instructions for each step are provided on subsequent pages. Example projects showing how to estimate the net GHG benefit and co-benefits from each project type are included in Appendix A.

Methods and equations used in the Wetlands Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool for estimating the net GHG benefit and co-benefits are provided in Appendix B. Methods and equations used in the Wetlands Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool for estimating other co-benefits and key variables not included in this Quantification Methodology are available at: [www.arb.ca.gov/cci-cobenefits](http://www.arb.ca.gov/cci-cobenefits). Emission factors used in calculations are contained in the Database available at: [www.arb.ca.gov/cci-resources](http://www.arb.ca.gov/cci-resources). Documentation on the sources and methods used to develop the emission factors are also provided.

#### Figure 1. Steps to Estimating Net GHG Benefit and Co-benefits



### Step 1: Define the Project

Applicants must define the project by identifying eligible components from Table 2 that apply to the project. Applicants may incorporate more than one project component and can use multiple methods identified in this Quantification Methodology, as appropriate, to quantify the net GHG benefit and air pollutant emission co-benefits. The project components identified will determine which subsections of this Quantification Methodology and sections of the accompanying Wetlands Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool must be used in order to estimate the net GHG benefit and air pollutant emission co-benefits.

- Wetland restoration in the legal Sacramento-San Joaquin Delta, as defined in California Water Code (CWC) section 12220, should be quantified using “Delta” worksheet.
- Coastal Tidal Wetland restorations are located within the coastal zone as defined in the California Coastal Act and the area of jurisdiction of the San Francisco Bay Conservation and Development Commission. Applicants proposing to restore these wetlands should use the “Coastal” worksheet, while restoration projects involving land-use change of farmland to coastal tidal wetland and upland should also include the “Coastal Farm” worksheet.
- Mountain meadow restoration activities should be quantified using the “Mtn. Meadow” worksheet.

**Table 1. Project Components and Appropriate Quantification Methods**

Project Component	Method Subsection References	Calculator Tool Worksheet
Land-Use Change from Farmland to Coastal Tidal Wetland/Upland	Step [2] Step [3]	“Coastal Farm” worksheet
Coastal Tidal Wetland Restoration	Step [2] Step [3]	“Coastal” worksheet
Sacramento-San Joaquin Delta Wetland Restoration	Step [2] Step [3]	“Delta” worksheet
Mountain Meadow Restoration	Step [2] Step [3]	“Mtn. Meadow” worksheet

## Step 2: Determine the Wetland Restoration Benefits Calculator Tool Inputs Needed

Table 2 identifies the required data inputs needed to estimate the net GHG benefit and co-benefits for the proposed project with the Wetland Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool by project type.

**Table 2. Required Wetland Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool Inputs for Eligible Project Type**

<b>ALL PROJECTS</b>
<p><b>General Information</b> (Read Me worksheet)</p> <ul style="list-style-type: none"> <li>• Project Name;</li> <li>• Grant ID;</li> <li>• Contact Name;</li> <li>• Contact Phone Number;</li> <li>• Contact Email; and</li> <li>• Date Completed.</li> <li>•</li> </ul> <p><b>Total Project GHG Benefit/GGRF \$ Requested</b> (GHG Summary worksheet)</p> <ul style="list-style-type: none"> <li>• Total amount of Wetlands Restoration for Greenhouse Gas Reduction Program GGRF funds requested from this solicitation to implement the project;</li> <li>• Total amount of additional GGRF funds to implement the project (include GGRF funds previously awarded to the project by the Department of Fish and Wildlife’s Wetland Restoration for Greenhouse Gas Reduction Program or another California Climate Investments program, GGRF funds currently being requested from another California Climate Investments program, and GGRF funds the project plans to request in the future from the Department of Fish and Wildlife’s Wetlands Restoration for Greenhouse Gas Reduction Program or another California Climate Investments program).</li> <li>• Identify California Climate Investments program(s) from which the project has been awarded GGRF funds (include award date), is currently requesting GGRF funds, or plans to request GGRF funds. For a list of GGRF funded programs, go to: <a href="http://www.arb.ca.gov/cci-events">www.arb.ca.gov/cci-events</a>.</li> </ul>
<b>SACRAMENTO-SAN JOAQUIN DELTA WETLAND RESTORATION</b>
<p><b>Quantification Inputs</b> (for “Delta” worksheet in Benefits Calculator Tool)</p> <ul style="list-style-type: none"> <li>• Acres restored to permanent wetland; and</li> <li>• Acres of farmland converted.</li> </ul>
<b>LAND-USE CHANGE FROM FARMLAND TO COASTAL TIDAL WETLAND/UPLAND</b>
<p><b>Quantification Inputs</b> (for “Coastal Farm” worksheet in Benefits Calculator Tool)</p> <ul style="list-style-type: none"> <li>• Acres converted from farmland to coastal tidal wetland; and</li> <li>• Acres converted from farmland to coastal upland.</li> </ul>



**Table 3. Required Wetland Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool Inputs for Eligible Project Type (cont'd.)**

<b>COASTAL TIDAL WETLAND RESTORATION</b>
<b>Quantification Inputs</b> (for “Coastal” worksheet in Benefits Calculator Tool) <ul style="list-style-type: none"><li>• Number of months per year water salinity is less than 18 ppt;</li><li>• If under existing conditions, project area is a seasonal wetland, number of months per year project area is inundated;</li><li>• If under existing conditions, project area is a seasonal wetland, number of months per year project area is inundated AND water salinity is less than 18 ppt;</li><li>• Acres project restores to tidal wetland; and</li><li>• Acres project restores to upland.</li></ul>
<b>MOUNTAIN MEADOW RESTORATION</b>
<b>Quantification Inputs</b> (for “Mtn. Meadow” worksheet in Benefits Calculator Tool) <ul style="list-style-type: none"><li>• Acres restored to mountain meadow.</li></ul>

### **Step 3: Estimate Net GHG Benefit and Co-benefits for the Proposed Project Using the Wetland Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool**

Applicants must use the Wetland Restoration Greenhouse Gas Reduction Program Benefits Calculator Tool to complete this step. The Benefits Calculator Tool can be downloaded from: [www.arb.ca.gov/cc-resources](http://www.arb.ca.gov/cc-resources).

Users should begin with the **Read Me** tab, which contains instructions and prompts users to enter project information.

The **calculation** tabs identify inputs required by the user, generally requiring project-specific data or assumptions. Input and output fields are color coded:

- **Yellow** fields indicate a direct user input is required.
- **Blue** fields indicate a user input is optional.
- **Gray** fields indicate output or calculation fields that are automatically populated based on user entries and the calculation methods.

Details of calculation methods are provided in Appendix B.

The **GHG Summary** tab displays the estimated:

- GHG benefit over the quantification period (MTCO<sub>2e</sub>);
- Total GHG benefit per total GGRF dollars requested (MTCO<sub>2e</sub>/);
- GHG benefit per Wetlands Restoration for Greenhouse Gas Reduction funds requested (MTCO<sub>2e</sub>/);<sup>1</sup>
- Wetlands Restoration for Greenhouse Gas Reduction funds requested per Wetlands Restoration for Greenhouse Gas Reduction funds GHG benefit (\$/MTCO<sub>2e</sub>); and
- Portion of the GHG benefit attributable to the GGRF funding from another CCI program, as applicable.

The **Co-benefits Summary** tab displays the estimated:

- Land Restored

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<sup>1</sup> This is the portion of GHG benefit attributable to funding from the Wetlands Restoration for Greenhouse Gas Reduction Program; GHG emission reductions are prorated according to the level of program funding contributed from the Wetland Restoration for Greenhouse Gas Reduction Program and other CCI programs, as applicable.

## Section C. Documentation

In addition to Wetlands Restoration for Greenhouse Gas Reduction Program application requirements, applicants for GGRF funding are required to document results from the use of this Quantification Methodology, including supporting materials to verify the accuracy of project-specific inputs.

Applicants are required to provide electronic documentation that is complete and sufficient to allow the calculations to be reviewed and replicated. Paper copies of supporting materials must be available upon request by agency staff.

The following checklist is provided as a guide to applicants; additional data and/or information may be necessary to support project-specific input assumptions.

	<b>Documentation Description</b>	<b>Completed</b>
1.	Contact information for the person who can answer project specific questions from staff reviewers on the quantification calculations	
2.	Project description, including excerpts or specific references to the location in the main Wetlands Restoration for Greenhouse Gas Reduction Program application of the project information necessary to complete the applicable portions of the Quantification Methodology	
3.	Populated Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool file (in .xlsx) with worksheets applicable to the project populated (ensure that all non-zero fields in the GHG Summary and Co-benefits tabs are populated)	
4.	Any other information as necessary and appropriate to substantiate Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool inputs (e.g., farming records, maps of project site)	

## Section D. Reporting after Funding Award

Accountability and transparency are essential elements for all California Climate Investments. All administering agencies are required to track project implementation and report on the benefits of those investments. CARB develops tracking and reporting guidance for California Climate Investments. The reporting process and requirements are found in CARB's Funding Guidelines for Agencies that Administer California Climate Investments (Funding Guidelines).<sup>2</sup>

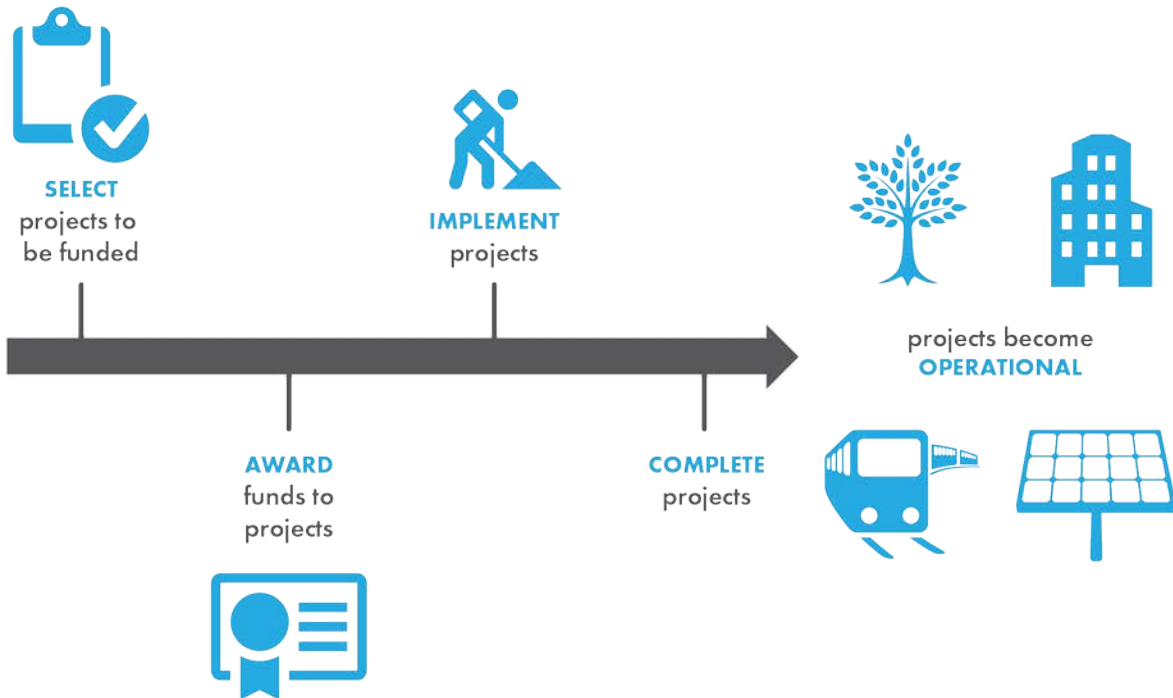
The Wetlands Restoration for Greenhouse Gas Reduction Program uses a two-step approach to quantification and reporting. In the two-step approach, net GHG benefit and select co-benefits are estimated twice for reporting purposes—once based on initial assumptions and again after implementation, based on reported project-level data.

CDFW will submit periodic reports to CARB. The specific data that need to be reported depend on the project type and the stage of project implementation at the time of reporting. Initially, administering agencies must report basic project information and expected benefits. As projects are implemented, administering agencies provide additional information on project status, benefits, and results. When projects are completed, administering agencies submit project closeout reports. A subset of projects, selected by CDFW, will report on project outcomes upon reaching a specified milestone and being considered “operational.” Reporting templates which contain detailed reporting requirements that are specific to each project type and cover all stages of reporting are available at: [www.arb.ca.gov/cci-resources](http://www.arb.ca.gov/cci-resources).

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<sup>2</sup> CARB released Draft Revised Funding Guidelines in April 2018. These Draft Revised Funding Guidelines are subject to change based on public input and Board direction. While the draft provides an indication of what is currently required, administering agencies must incorporate all provisions reflected in the Draft Revised Funding Guidelines and subsequent Board approved Funding Guidelines.

Quantification Methodology for the Department of Fish and Wildlife  
Wetland Restoration for Greenhouse Gas Reduction Program



CDFW is required to collect and compile project data from funding recipients, including the net GHG benefit estimated using this Quantification Methodology, co-benefits, and information on benefits to priority populations.<sup>3</sup> Reported information will be used to demonstrate how the Administration is achieving or exceeding the statutory objectives for California Climate Investments. Select co-benefit and key variable estimates are highlighted in the Co-benefits Summary tab of the Wetlands Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool. Funding recipients have the obligation to provide, or provide access to, data and information on project outcomes to CDFW. Applicants should familiarize themselves with the requirements within the Wetlands Restoration for Greenhouse Gas Reduction Program Proposal Solicitation Notice (PSN), solicitation materials, and grant agreement, as well as the CARB Funding Guidelines.

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<sup>3</sup> Priority populations include residents of: (1) census tracts identified as disadvantaged by the California Environmental Protection Agency per Senate Bill (SB) 535; (2) census tracts identified as low-income per Assembly Bill (AB) 1550; or (3) a low-income household per AB 1550. Detailed information is provided in CARB's Funding Guidelines.

## Section E. References

The following references were used in the development of this Quantification Methodology and the accompanying Wetland Restoration Greenhouse Gas Reduction Program Benefits Calculator Tool.

American Carbon Registry. (2017). *Methodology for the Quantification, Monitoring, Reporting and Verification of Greenhouse Gas Emissions Reductions and Removals from the Restoration of California Deltaic and Coastal Wetlands*. Arlington: Deverel, S., Oikawa, P., Dore, S., Mack, S., and Silva, L. <https://americancarbonregistry.org/carbon-accounting/standards-methodologies/restoration-of-california-deltaic-and-coastal-wetlands/ca-wetland-methodology-v1.1-November-2017.pdf>.

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McNicol, G., Sturtevant, C.S., Knox, S.H., Dronova, I., Baldocchi, D.D., Silver, W.L. (2016). Effects of seasonality, transport pathway, and spatial structure on greenhouse gas fluxes in a restored wetland. *Global Change Biology*, 23(7) 2768-2782. <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.13580>.

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<sup>i</sup> CDFW Wetlands Restoration for Greenhouse Gas Reduction Program <https://www.wildlife.ca.gov/Conservation/Watersheds/Greenhouse-Gas-Reduction>

<sup>ii</sup> California Air Resources Board. [www.arb.ca.gov/cci-fundingguidelines](http://www.arb.ca.gov/cci-fundingguidelines)

<sup>iii</sup> California Air Resources Board. [www.arb.ca.gov/cci-resources](http://www.arb.ca.gov/cci-resources)

<sup>iv</sup> Wetlands Restoration for Greenhouse Gas Reduction Program Interim Quantification Methodology for FY 2014-15. <https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/cdfwwetlandsqm.pdf>

## Appendix A. Example Project

### Introduction

The following are hypothetical projects<sup>4</sup> to demonstrate how the Wetlands Restoration for Greenhouse Gas Reduction Program Quantification Methodology would be applied. These hypothetical projects do not provide examples of the supporting documentation that is required of actual project applicants.

### A. Delta Wetland Restoration in San Joaquin County

The proposed project is a Farm-to-Managed Wetlands project proposing the following components:

- Sacramento-San Joaquin Delta Wetland Restoration

The proposed project has the following project features:

- 27 acres of farmland to be converted to permanently flooded, managed wetland
- 3 acres of waterlogged land to be converted to permanently flooded, managed wetland
- \$400,000 requested from Wetlands Restoration for Greenhouse Gas Reduction Fund

### Methods to apply

#### Step 1: Define the Project

Refer to Table 2 to match project components with the steps required to quantify the net GHG benefits. More than one component may apply to a single project.

The project components that apply to this project is “Sacramento-San Joaquin Delta Wetland Restoration.” The applicant will need to follow Steps 2 and 3 to complete the quantification. Using Table 2, the applicant determines that the applicant will need to use the “Delta” worksheet of the Benefits Calculator Tool.

#### Step 2: Determine the Wetlands Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool Inputs Needed

The applicant determines all of the required inputs from Table 3 to estimate net GHG benefits. There is General Information that all applicants must submit. That information is entered in the “Read Me” worksheet of the Benefits Calculator Tool.

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<sup>4</sup> The hypothetical project has not undergone verification of any Wetlands Restoration for Greenhouse Gas Reduction Program requirements; all assumptions about location type and project features are for quantification methodology demonstration purposes only.



Quantification Methodology for the Department of Fish and Wildlife  
Wetland Restoration for Greenhouse Gas Reduction Program

<b>Project Name:</b>	San Joaquin Old River Association
<b>Application ID:</b>	SOA-Example
<b>Contact Name:</b>	Jane Doe
<b>Contact Phone Number:</b>	559-555-0199
<b>Contact Email:</b>	Jane.Doe@soa.river
<b>Date Completed:</b>	6/29/2018

Total Project GHG Benefit will be estimated by the Benefits Calculator Tool. Because the project area has different areas with different characteristics, the areas will be tracked separately.

For the “Sacramento-San Joaquin Delta Wetland Restoration” project component, the quantification inputs required are:

- Acres restored to permanent wetland: 30 acres (27 acres from farmland, 3 acres waterlogged)
- Acres restored to upland: 0 acres
- Acres of farmland converted: 27 acres
- No additional funds requested from other GGRF Programs

### Step 3: Estimate Net GHG Benefit and Co-benefits for the Proposed Project Using the Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool

Project GHG benefits and co-benefits are calculated using the Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool. The applicant enters the inputs into the “Delta” tab.

“Delta” worksheet inputs look like this:

**Delta Restoration Worksheet**

Area	GHG Calculation Inputs	
	Acres Restored to Permanent Wetland	Acres Converted from Farmland
1	30 acres	27 acres
2	acres	acres
3	acres	acres
4	acres	acres
5	acres	acres
<b>SUBTOTAL</b>	<b>30 acres</b>	<b>27 acres</b>

In the “GHG Summary” tab, the applicant enters the funds requested. The Benefits Calculator Tool determines the GHG benefits and associated accounting statistics.

**Quantification Methodology for the Department of Fish and Wildlife  
Wetland Restoration for Greenhouse Gas Reduction Program**

**Greenhouse Gas Summary**

Total amount of Wetland Restoration for Greenhouse Gas Reduction GGRF funds requested from this solicitation to implement the project	\$400,000
Total amount of additional GGRF funds to implement the project	
Identify California Climate Investment programs from which the project has been awarded GGRF funds, is currently requesting GGRF funds, or plans to request GGRF funds	
California Climate Investment Program	Award Date if Awarded

GHG benefit over the quantification period	11,597	MT-CO <sub>2</sub> e
Total GHG benefit per total GGRF dollars requested	0.02899	MT-CO <sub>2</sub> e/\$
GHG benefit per Wetlands Restoration funds requested	0.02899	MT-CO <sub>2</sub> e/\$
Wetland Restoration funds requested per Wetland Restoration GHG benefit	34	\$/MT-CO <sub>2</sub> e
Portion of the GHG benefit attributable to the GGRF funding from another CCI program		MT-CO <sub>2</sub> e

The project is estimated to have a benefit of 9,564 MT-CO<sub>2</sub>e.

In the “Co-Ben Summary” worksheet, the Benefits Calculator Tool determines the co-benefits associated with the project.

**Co-Benefits Summary**

KEY VARIABLES	Delta Wetlands	Coastal Wetlands	Coastal Uplands	Mountain Meadows	Total Land Restored	
Land Restored/Treated	30				30	Acres

The project will restore 30 acres of Delta wetland.

## **B. Farm to Coastal Tidal Wetland in Ventura County**

### **Overview of the proposed project**

The proposed project is a Coastal Tidal Wetlands project proposing the following components:

- Coastal Tidal Wetlands Restoration

The proposed project has the following project features:

- \$750,000 requested from the Wetlands Restoration for Greenhouse Gas Reduction Fund
- No additional funds requested from other GGRF Programs

#### Area 1

- 30 acres of farmland to be converted to permanent coastal tidal wetland

#### Area 2

- 10 acres of farmland to be converted to coastal upland
- 5 acres of tidal wetland threatened by sea-level rise to be restored
- 4 acres of degraded upland to be restored

## Methods to apply

### Step 1: Define the Project

Refer to Table 2 to match project components with the steps required to quantify the net GHG benefits. More than one component may apply to a single project.

The project components that apply to this project is “Land-Use Change from Farmland to Coastal Wetland/Upland” and “Coastal Wetlands Restoration.” The applicant will need to follow Steps 2 and 3 to complete the quantification. Using Table 2, the applicants determines that the applicant will need to use the “Coastal Farm” worksheet and the “Coastal” worksheet of the Benefits Calculator Tool.

### Step 2: Determine the Wetlands Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool Inputs Needed

The applicant determines all of the required inputs from Table 3 to estimate net GHG benefits. There is General Information that all applicants must submit. That information is entered in the “Read Me” worksheet of the Benefits Calculator Tool.

<b>Project Name:</b>	Suisun Solano Project
<b>Application ID:</b>	SSP-Example
<b>Contact Name:</b>	Jonathon Smith
<b>Contact Phone Number:</b>	805-555-0192
<b>Contact Email:</b>	jdoe@ventura.com
<b>Date Completed:</b>	6/25/2018

Total Project GHG Benefit will be estimated by the Benefits Calculator Tool. Because the project area has different areas with different characteristics, the areas will be tracked separately.

## Area 1

For the “Land-Use Change from Farmland to Coastal Tidal Wetland/Upland” project component, the quantification inputs required are:

- Acres converted from farmland to coastal tidal wetland: 30 acres
- Acres converted from farmland to coastal tidal upland: 0 acres

For the “Coastal Tidal Wetland Restoration” project component, the quantification inputs required are:

- Number of months per year water salinity is less than 18 ppt: wetland is coastal, water salinity is always greater than 18 ppt: 0 months
- If project area is a seasonal wetland, number of months per year project area is inundated: area is not a seasonal wetland; 0 months
- If project area is a seasonal wetland, number of months per year project area is inundated AND water salinity is less than 18 ppt: 0 months
- Acres project restores to permanent tidal wetland: 30 acres
- Acres project restores to upland: 0 acres

## Area 2

For the “Land-Use Change from Farmland to Coastal Tidal Wetland/Upland” project component, the quantification inputs required are:

- Acres converted from farmland to coastal tidal wetland: 0 acres
- Acres converted from farmland to coastal upland: 10 acres

For the “Coastal Tidal Wetland Restoration” project component, the quantification inputs required are:

- If project area is a seasonal wetland, number of months per year project area is inundated: area is not a seasonal wetland; 0 months
- Number of months per year water salinity is less than 18 ppt: wetland is coastal, water salinity is always greater than 18 ppt: 0 months
- If project area is a seasonal wetland, number of months per year project area is inundated AND water salinity is less than 18 ppt: 0 months
- Acres project restores to permanent tidal wetland: 5 acres
- Acres project restores to upland: 14 acres (10 acres of farmland restored to upland, 4 acres of degraded upland restored)

### Step 3: Estimate Net GHG Benefit and Co-benefits for the Proposed Project Using the Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool

Project GHG benefits and co-benefits are calculated using the Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool. The applicant enters the inputs into the “Coastal Farm” worksheet and “Coastal” worksheet.

“Coastal Farm” worksheet inputs look like this:

#### Land-Use Change from Coastal Farmland Worksheet

Use this sheet and the "Coastal" sheet for farmland converted to coastal tidal wetland or coastal upland.

Area	Project Component Inputs	
	Farmland area converted to permanent coastal tidal wetland	Farmland area converted to coastal upland
1	30 acres	0 acres
2	0 acres	10 acres
3	acres	acres
4	acres	acres
5	acres	acres
SUBTOTAL	30 acres	10 acres

“Coastal” worksheet inputs look like this:

#### Coastal Tidal Wetland and Upland Restoration Worksheet

Use this sheet for land (including farmland) converted to coastal tidal wetland or coastal upland.

Area	GHG Calculation Inputs					
	Months per year water salinity is less than 18 ppt	If Area is initially seasonal wetland, months per year site is inundated		If Area is initially seasonal wetland, months per year site is inundated and water salinity less than 18 ppt		Area restored to permanent coastal tidal wetland
1	0 months	0 months	0 months	0 months	30 acres	0 acres
2	0 months	0 months	0 months	0 months	5 acres	14 acres
3	months	months	months	months	acres	acres
4	months	months	months	months	acres	acres
5	months	months	months	months	acres	acres
SUBTOTAL					35 acres	14 acres

**Quantification Methodology for the Department of Fish and Wildlife  
Wetland Restoration for Greenhouse Gas Reduction Program**

In the “GHG Summary” tab, the applicant enters the funds requested. The Benefits Calculator Tool determines the GHG benefits and associated accounting statistics.

**Greenhouse Gas Summary**

Total amount of Wetland Restoration for Greenhouse Gas Reduction GGRF funds requested from this solicitation to implement the project	\$750,000
Total amount of additional GGRF funds to implement the project	
Identify California Climate Investment programs from which the project has been awarded GGRF funds, is currently requesting GGRF funds, or plans to request GGRF funds	
California Climate Investment Program	Award Date if Awarded

GHG benefit over the quantification period	16,965	MT-CO <sub>2</sub> e
Total GHG benefit per total GGRF dollars requested	0.02262	MT-CO <sub>2</sub> e/\$
GHG benefit per Wetlands Restoration funds requested	0.02262	MT-CO <sub>2</sub> e/\$
Wetland Restoration funds requested per Wetland Restoration GHG benefit	44	\$/MT-CO <sub>2</sub> e
Portion of the GHG benefit attributable to the GGRF funding from another CCI program		MT-CO <sub>2</sub> e

The project is estimated to have a benefit of 32,239 MT-CO<sub>2</sub>e.

In the “Co-Ben Summary” tab, the Benefits Calculator Tool determines the co-benefits associated with the project.

**Co-Benefits Summary**

KEY VARIABLES	Delta Wetlands	Coastal Wetlands	Coastal Uplands	Mountain Meadows	Total Land Restored	
Land Restored/Treated		35	14		49	Acres

The project will restore 35 acres of coastal wetland and 14 acres of upland.

## C. Seasonal Wetland to Permanent Coastal Tidal Wetland in Suisun Marsh

### Overview of the proposed project

The proposed project is a Coastal Wetlands project proposing the following components:

- Coastal Tidal Wetland Restoration

The proposed project has the following project features:

- 17 acres of seasonal wetland to be converted to permanent tidal wetland
- Area dries out in summertime: project area is inundated 5 months out of the year
- During the wet season (3 months), water salinity is less than 5 ppt. During other months of the year, water salinity is typically between 20 and 25 ppt
- Water salinity is less than 5 ppt for 3 months during the 5 months of area inundation. Water salinity is between 20 and 25 ppt for the other 2 months
- 5 acres of degraded upland to be restored with native grasses and shrubs
- \$200,000 requested from the Wetlands Restoration for Greenhouse Gas Reduction Fund
- No additional funds requested from other GGRF Programs

### Methods to apply

#### Step 1: Define the Project

Refer to Table 2 to match project components with the steps required to quantify the net GHG benefits. More than one component may apply to a single project.

The project component that applies to this project is Coastal Tidal Wetland Restoration. The applicant will need to follow Steps 2 and 3 to complete the quantification. Using Table 2, the applicant determines that the applicant will need to use the “Coastal” worksheet of the Benefits Calculator Tool.

#### Step 2: Determine the Wetlands Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool Inputs Needed

The applicant determines all of the required inputs from Table 3 to estimate net GHG benefits. There is General Information that all applicants must submit. That information is entered in the “Read Me” worksheet of the Benefits Calculator Tool.

Project Name:  
Application ID:  
Contact Name:  
Contact Phone Number:  
Contact Email:  
Date Completed:

Suisun Solano Project
SSP-Example
Jonathon Smith
707-555-0192
jonathon.smith@ventura.com
6/26/2018

Total Project GHG Benefit will be estimated by the Benefits Calculator Tool.

For the Wetland/Upland Restoration, the quantification inputs required are:

- Number of months per year water salinity is less than 18 ppt: 3 months
- If project area is a seasonal wetland, number of months per year project area is inundated: 5 months
- Acres restored to permanent wetland: 17 acres
- If project area is a seasonal wetland, number of months per year project area is inundated AND water salinity is less than 18 ppt: 3 months
- Acres restored to upland: 5 acres

### Step 3: Estimate Net GHG Benefit and Co-benefits for the Proposed Project Using the Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool

Project GHG benefits and co-benefits are calculated using the Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool. The applicant enters the inputs into the “Coastal” worksheet.

#### Coastal Tidal Wetland and Upland Restoration Worksheet

Area	GHG Calculation Inputs									
	Months per year water salinity is less than 18 ppt		If Area is Initially Seasonal Wetland, Months per Year site is Inundated		If Area is Initially Seasonal Wetland, Months per year site is Inundated and water salinity less than 18 ppt		Area Restored to Permanent Coastal Tidal Wetland		Area Restored to Coastal Upland	
1	3	months	5	months	3	months	17	acres	5	acres
2		months		months		months		acres		acres
3		months		months		months		acres		acres
4		months		months		months		acres		acres
5		months		months		months		acres		acres
SUBTOTAL							17	acres	5	acres

In the “GHG Summary” tab, the applicant enters the funds requested. The Benefits Calculator Tool determines the GHG benefits and associated accounting statistics.



**Quantification Methodology for the Department of Fish and Wildlife  
Wetland Restoration for Greenhouse Gas Reduction Program**

**Greenhouse Gas Summary**

Gas Reduction GGRF funds requested from this solicitation to implement the project:	\$200,000
Total amount of additional GGRF funds to implement the project	
Identify California Climate Investment programs from which the project has been awarded GGRF funds, is currently requesting GGRF funds, or plans to request GGRF funds.	
California Climate Investment Program	Award Date if Awarded

GHG benefit over the quantification period	857	MT-CO <sub>2</sub> e
Total GHG benefit per total GGRF dollars requested	0.00429	MT-CO <sub>2</sub> e/\$
GHG benefit per Wetlands Restoration funds requested	0.00429	MT-CO <sub>2</sub> e/\$
Wetland Restoration funds requested per Wetland Restoration GHG benefit	233	\$/MT-CO <sub>2</sub> e
Portion of the GHG benefit attributable to the GGRF funding from another CCI program	0	MT-CO <sub>2</sub> e

The project is estimated to have a benefit of 857 MT-CO<sub>2</sub>e.

In the “Co-Ben Summary” tab, the Benefits Calculator Tool determines the co-benefits associated with the project.

**Co-Benefits Summary**

KEY VARIABLES	Delta Wetlands	Coastal Wetlands	Coastal Uplands	Mountain Meadows	Total Land Restored	
Land Restored/Treated		17	5		22	Acres

The project will restore 17 acres of coastal tidal wetlands and 5 acres of uplands.

## D. Mountain Meadow in Tuolumne County

### Overview of the proposed project

The proposed project is a Mountain Meadow Ecosystems project proposing the following components:

- Restoration of a degraded Mountain Meadow

The proposed project has following project features:

- 36 acres of degraded Mountain Meadow to be restored
- \$600,000 requested from the Wetlands Restoration for Greenhouse Gas Reduction Program.
- No additional funds requested from other GGRF Programs

### Methods to apply

#### Step 1: Define the Project

Refer to Table 2 to match project components with the steps required to quantify the net GHG benefits. More than one component may apply to a single project.

The project component that applies to this project is Mountain Meadow Restoration. The applicant will need to follow Steps 2 and 3 to complete the quantification. Using Table 2, the applicant determines that the applicant will need to use the “Mtn. Meadow” worksheet of the Benefits Calculator Tool.

#### Step 2: Determine the Wetlands Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool Inputs Needed

The applicant determines all of the required inputs from Table 3 to estimate net GHG benefits. There is General Information that all applicants must submit. That information is entered in the “Read Me” worksheet of the Benefits Calculator Tool.

<b>Project Name:</b>	<b>Mountain Meadow Admirers</b>
<b>Application ID:</b>	<b>MMA-Example</b>
<b>Contact Name:</b>	<b>Janet Smith</b>
<b>Contact Phone Number:</b>	<b>209-555-0191</b>
<b>Contact Email:</b>	<b>smithj@mma.mtn</b>
<b>Date Completed:</b>	<b>6/28/2018</b>

Total Project GHG Benefit will be estimated by the Benefits Calculator Tool.

For the Mountain Meadow Restoration, the quantification inputs required are:

- Acres restored to mountain meadow: 36 acres

### Step 3: Estimate Net GHG Benefit and Co-benefits for the Proposed Project Using the Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool

Project GHG benefits and co-benefits are calculated using the Wetland Restoration for Greenhouse Gas Reduction Benefits Calculator Tool. The applicant enters the inputs into the “Mtn. Meadow” worksheet.

#### Mountain Meadow Restoration Worksheet

Area	GHG Calculation Inputs	
	Acres Restored to Mountain Meadow	
1	36	acres
2		acres
3		acres
4		acres
5		acres
SUBTOTAL	36	acres

In the “GHG Summary” tab, the applicant enters the funds requested. The Benefits Calculator Tool determines the GHG benefits and associated accounting statistics.

#### Greenhouse Gas Summary

Gas Reduction GGRF funds requested from this solicitation to implement the project:	\$600,000
Total amount of additional GGRF funds to implement the project	
Identify California Climate Investment programs from which the project has been awarded GGRF funds, is currently requesting GGRF funds, or plans to request GGRF funds.	
California Climate Investment Program	Award Date if Awarded

GHG benefit over the quantification period	2,548	MT-CO <sub>2</sub> e
Total GHG benefit per total GGRF dollars requested	0.00425	MT-CO <sub>2</sub> e/\$
GHG benefit per Wetlands Restoration funds requested	0.00425	MT-CO <sub>2</sub> e/\$
Wetland Restoration funds requested per Wetland Restoration GHG benefit	235	\$/MT-CO <sub>2</sub> e
Portion of the GHG benefit attributable to the GGRF funding from another CCI program	0	MT-CO <sub>2</sub> e

The project is estimated to have a benefit of 2,548 MT-CO<sub>2</sub>e.

In the “Co-Ben Summary” tab, the Benefits Calculator Tool determines the co-benefits associated with the project.

**Co-Benefits Summary**

KEY VARIABLES	Delta Wetlands	Coastal Wetlands	Coastal Uplands	Mountain Meadows	Total Land Restored
Land Restored/Treated				36	36

Acres

The project will restore 36 acres of Mountain Meadow.

## Appendix B. Equations Supporting Estimates in the Wetland Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool

Methods used in the Wetland Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool for estimating the net GHG benefit and co-benefits by activity type are provided in this appendix. The Database Documentation explain how emission factors used in CARB quantification methodologies are developed and updated.

These methods account for changes in soil organic carbon and carbon sequestration, changes in methane emission from wetland restoration, and changes in nitrous oxide emissions from land use change from farming. In general, the net GHG benefit is estimated in the Wetland Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool using the following approaches in Table 3. The Wetland Restoration for Greenhouse Gas Reduction Program Benefits Calculator Tool also estimates co-benefits and key variables using largely the same inputs used to estimate the net GHG benefit.

**Table 4. General Approach to Quantification by Project Type**

SACRAMENTO-SAN JOAQUIN DELTA WETLANDS (Legal Delta Boundary)
<i>Net GHG Benefit = Avoided Organic Matter Decomposition + Avoided N2O Emissions from Farmland Use Conversion + Change in CO2 and CH4 Emissions from Restored Delta Wetland</i>
COASTAL TIDAL WETLANDS
Net GHG Benefit = GHG Emissions Avoided from Farmland Use Conversion – CH4 Emissions from Rewetted Land + Carbon Sequestered in Restored Wetland + Carbon Sequestered in Restored Adjacent Uplands
MOUNTAIN MEADOW ECOSYSTEMS
Net GHG Benefit = Carbon Sequestered in Restored Mountain Meadow Soil

## A. GHG Benefit Estimate from Sacramento-San Joaquin Delta Wetland Restoration

The GHG benefit from Sacramento-San Joaquin Delta Wetland Restoration is estimated using Equation 1.

**Equation 1: GHG Benefit from Sacramento-San Joaquin Delta Wetland Restoration**

$$GHG_{RDW} = \left( 0.05 \times 40,468,564 \div 1,000,000 \times \frac{44}{12} - 2.60 \times 0.4047 \right) \times A_{RDW} \times 50 + 298 \times 0.008 \times 0.4047 \times \frac{44}{28} \times A_F \times 50$$

<i>Where,</i>		<u>Units</u>
$GHG_{RDW}$	= GHG benefit of restored Delta wetland	MT CO <sub>2</sub> e
0.05	= Drained organic soil carbon loss rate	$\frac{\text{g C}}{\text{cm}^2 \text{ Year}}$
40,468,564	= Conversion from square centimeters to acres	$\frac{\text{cm}^2}{\text{Acre}}$
1,000,000	= Conversion from grams to metric tons	$\frac{\text{g}}{\text{MT}}$
$\frac{44}{12}$	= Molecular weight ratio of carbon dioxide to carbon	$\frac{\text{MT CO}_2\text{e}}{\text{MT C}}$
2.60	= Restored Delta wetland CO <sub>2</sub> and CH <sub>4</sub> emission rate	$\frac{\text{MT CO}_2\text{e}}{\text{HectareYear}}$
0.4047	= Conversion from hectares to acres	$\frac{\text{Hectares}}{\text{Acres}}$
$A_{RDW}$	= Area of restored delta wetland	Acres
50	= Number of years of project life	Years
298	= Nitrous oxide global warming potential	$\frac{\text{MT CO}_2\text{e}}{\text{MT N}_2\text{O}}$
0.008	= Nitrous oxide emission rate for cropped wetland soils	$\frac{\text{MT N}_2\text{O} - \text{N}}{\text{Hectare Year}}$
0.4047	= Conversion from hectares to acres	$\frac{\text{Hectares}}{\text{Acres}}$
$\frac{44}{28}$	= Molecular weight ratio of nitrous oxide to nitrogen	$\frac{\text{MT N}_2\text{O}}{\text{MT N}}$
$A_F$	= Area of farmland converted to managed wetland	Acres

## B. GHG Benefit Estimate from Land-Use Change from Farmland to Coastal Tidal Wetlands and Uplands

The GHG benefit from land-use change from farmland on organic soils is estimated using Equation 2, which relies on three other equations. Equation 3 is used to determine the value for the difference in carbon loss rates ( $\Delta CLR$ ) from land-use change from farmland that will be restored to coastal wetland for Equation 2. Equation 4 is used to determine the value for carbon sequestration ( $C_{seqF-U}$ ) from land-use change from farmland that will be restored to coastal upland for Equation 2. Equation 5 is used to determine the avoided N<sub>2</sub>O emissions ( $\Delta N_2O$ ) in Equation 2 from avoided nitrogen application.

Equation 2 must be used in conjunction with Equation 6 (GHG Benefit from Coastal Tidal Wetland and Upland Restoration) to determine the Net GHG Benefit from first converting farmland to become coastal tidal wetlands and uplands, and then restoring the coastal tidal wetlands and uplands.

### Equation 2: GHG Benefit from Land-Use Change from Farmland to Coastal Tidal Wetlands and Uplands

$$GHG_{LUC} = (\Delta CLR + \Delta N_2O \times 298) \times 50 + C_{seqF-U}$$

Where,

		Units
$GHG_{LUC}$	= GHG benefit of land-use change from farmland	MT CO <sub>2</sub> e
$\Delta CLR$	= Avoided carbon loss rate of farmland on drained organic soil to be restored to coastal tidal wetland (from Equation 3)	$\frac{MT CO_2e}{Year}$
$\Delta N_2O$	= Change in nitrous oxide emissions from drained organic soil (Equation 5)	$\frac{MT N_2O}{Year}$
298	= Nitrous oxide global warming potential	$\frac{MT CO_2e}{MT N_2O}$
50	= Number of years of project life	Years
$C_{seqF-U}$	= Carbon sequestration from conversion of farmland to be restored to coastal upland (Equation 4)	MT CO <sub>2</sub> e

**Equation 3: Carbon Loss Rate Change from Conversion of Farmland to be Restored to Coastal Wetland**

$$\Delta CLR = \left( 0.05 \times 40,468,564 \div 1,000,000 \times \frac{44}{12} \right) \times A_{F-CTW}$$

<i>Where,</i>		<u>Units</u>
$\Delta CLR$	= Change in carbon loss rate from project implementation	$\frac{MT\ CO_2e}{Acre\ Year}$
0.05	= Drained organic soil carbon loss rate	$\frac{g\ C}{cm^2\ Year}$
40,468,564	= Conversion from square centimeters to acres	$\frac{cm^2}{Acre}$
1,000,000	= Conversion from grams to metric tons	$\frac{g}{MT}$
$\frac{44}{12}$	= Molecular weight ratio of carbon dioxide to carbon	$\frac{MT\ CO_2}{MT\ C}$
$A_{F-CTW}$	= Area of farmland converted to be restored to coastal tidal wetland	Acres

**Equation 4: Carbon Sequestration Change from Conversion of Farmland to be Restored to Coastal Upland**

$$Cseq_{F-CU} = (CS_{ref} \times F_{LU,G} \times F_{GM,SD} \times A_{F-CU} - CS_{ref} \times F_{LU,C} \times F_{CM,FT} \times A_{F-CU}) \times 0.4047 \times \frac{44}{12}$$

<i>Where,</i>		<u>Units</u>
$Cseq_{F-CU}$	= Total carbon sequestration from conversion of farmland to be restored to coastal upland	MT CO <sub>2</sub> e
$CS_{ref}$	= Reference carbon stock for warm temperate dry wetland soils (48)	$\frac{MT\ C}{Hectare}$
$F_{LU,G}$	= Land use factor, grassland for warm temperate dry climate (1.37)	
$F_{GM,SD}$	= Grassland management factor, severely degraded (0.7)	
$A_{F-CU}$	= Area converted from farmland to coastal upland	Acres
$F_{LU,C}$	= Land use Factor, cultivated (1)	
$F_{CM,FT}$	= Cropland management factor, full till (1)	
0.4047	= Conversion from hectares to acres	$\frac{Hectares}{Acres}$



$\frac{44}{12}$	=	Molecular weight ratio of carbon dioxide to carbon	$\frac{\text{MT CO}_2\text{e}}{\text{MT C}}$
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**Equation 5: Avoided Nitrous Oxide Emissions from Cultivated and Drained Organic Soils**

$$\Delta N_2O = 0.008 \times A_F \times 0.4047 \times \frac{44}{28}$$

Where,

		<u>Units</u>	
$\Delta N_2O$	=	Change in Nitrous Oxide emissions from project implementation	$\frac{\text{MT N}_2\text{O}}{\text{Year}}$
0.008	=	Nitrous oxide emission rate for cropped wetland soils	$\frac{\text{MT N}_2\text{O} - \text{N}}{\text{Hectare Year}}$
$A_F$	=	Area of farmland converted to coastal tidal wetland and upland	Acres
0.4047	=	Conversion from hectares to acres	$\frac{\text{Hectares}}{\text{Acres}}$
$\frac{44}{28}$	=	Molecular weight ratio of nitrous oxide to nitrogen	$\frac{\text{MT N}_2\text{O}}{\text{MT N}}$

### C. GHG Benefit Estimate from Coastal Tidal Wetland and Upland Restoration

The GHG benefit from Wetland/Upland Restoration is estimated using Equation 6, which relies on three other equations. Equations 7 and 8 are used to determine the carbon sequestration ( $Cseq_{CTW}$ ,  $Cseq_{CU}$ ) from restoration of wetlands and uplands in Equation 6. Equation 9 is used to determine the change in methane emissions ( $\Delta CH_4$ ) from restoration of wetlands in Equation 7.

**Equation 6: GHG Benefit from Coastal Tidal Wetland and Upland Restoration**

$$GHG_{Coastal} = Cseq_{CTW} + Cseq_{CU} - \Delta CH_4 \times 25$$

Where,

		<u>Units</u>	
$GHG_{Coastal}$	=	GHG benefit of coastal tidal wetland and upland restoration	MT CO <sub>2</sub> e
$Cseq_{CTW}$	=	Total carbon sequestration from coastal tidal wetlands restoration (Equation 7)	MT CO <sub>2</sub> e
$Cseq_{CU}$	=	Total carbon sequestration from restoration of coastal upland (Equation 8)	MT CO <sub>2</sub> e
$\Delta CH_4$	=	Total change in methane emissions from coastal tidal wetlands restoration (Equation 9)	MT CH <sub>4</sub>

25	= Methane global warming potential	$\frac{\text{MT CO}_2\text{e}}{\text{MT CH}_4}$
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**Equation 7: Carbon Sequestration from Coastal Tidal Wetlands Restoration**

$$C_{seq_{CTW}} = 79 \times A_{CTW} \times \left(1 - \frac{Freq_{wet}}{12}\right) \times 4,046.86 \div 1,000,000 \times \frac{44}{12} \times 50$$

<i>Where,</i>		<u>Units</u>
$C_{seq_{CTW}}$	= Total carbon sequestration from coastal tidal wetlands restoration	MT CO <sub>2</sub> e
79	= Annual carbon sequestration coefficient for wetland restoration	$\frac{\text{g C}}{\text{m}^2\text{Year}}$
$A_{CTW}$	= Coastal wetland area restored	Acres
$Freq_{wet}$	= Number of months project area existed as a seasonal wetland before conversion or restoration to permanent wetland	Months
12	= Months per Year	Months
4046.86	= Conversion from square meters to acres	$\frac{\text{m}^2}{\text{Acres}}$
1,000,000	= Conversion from grams to metric tons	$\frac{\text{g}}{\text{MT}}$
$\frac{44}{12}$	= Molecular weight ratio of carbon dioxide to carbon	$\frac{\text{MT CO}_2\text{e}}{\text{MT C}}$
50	= Number of years of project life	Years

**Equation 8: Carbon Sequestration from Coastal Upland Restoration**

$$C_{seq_{CU}} = (CS_{ref} \times F_{LU,G} \times F_{GM,I} \times F_{GI,HI} \times A_{CU} - CS_{ref} \times F_{LU,G} \times F_{GM,SD} \times A_{CU}) \times 0.4047 \times \frac{44}{12}$$

<i>Where,</i>		<u>Units</u>
$C_{seq_{UP}}$	= Total carbon sequestration from upland restoration	MT CO <sub>2</sub> e
$CS_{ref}$	= Reference carbon stock for warm temperate dry wetland soils (48)	$\frac{\text{MT C}}{\text{Hectare}}$
$F_{LU,G}$	= Land use factor, grasslands for warm temperate dry climate (1.37)	
$F_{GM,I}$	= Grassland management factor, improved (1.14)	
$A_{CU}$	= Area restored to coastal upland	Acres
$F_{GM,SD}$	= Grassland management factor, severely degraded (0.7)	
0.4047	= Conversion from hectares to acres	$\frac{\text{Hectares}}{\text{Acres}}$

$\frac{44}{12}$	=	Molecular weight ratio of carbon dioxide to carbon	$\frac{\text{MT CO}_2\text{e}}{\text{MT C}}$
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**Equation 9: Change in Methane Emissions from Coastal Tidal Wetland Restoration**

$$\Delta CH_4 = 193.7 \times A_{CTW} \times \left( \frac{Freq_{Fresh} - Freq_{FreshWet}}{12} \right) \times 0.4047 \div 1,000 \times 50$$

Where,			<u>Units</u>
$\Delta CH_4$	=	Change in methane emissions	MT CH <sub>4</sub>
193.7	=	Methane emission factor for wetlands with salinity less than 18 ppt	$\frac{\text{kg CH}_4}{\text{HectareYear}}$
$A_{CTW}$	=	Area restored to coastal tidal wetland	Acres
$Freq_{Fresh}$	=	Number of months restored permanent wetland has salinity less than 18 ppt	Months
$Freq_{FreshWet}$	=	Number of months the project area existed as a seasonal wetland with salinity less than 18 ppt before conversion or restoration to permanent tidal wetland	Months
12	=	Months per year	Months
0.4047	=	Conversion from hectares to acres	$\frac{\text{Hectares}}{\text{Acres}}$
1,000	=	Conversion from kg to metric tons	$\frac{\text{kg}}{\text{MT}}$
50	=	Number of years of project life	Years

## D. GHG Benefit Estimate from Mountain Meadow Restoration

The GHG benefit from Mountain Meadow Restoration is estimated as the increase in soil carbon sequestration using Equation 10.

### Equation 10: GHG Benefit from Mountain Meadow Restoration

$$C_{seq_{MM}} = 95.40 \times A_{MM} \times 4,046.86 \div 1,000,000 \times \frac{44}{12} \times 50$$

Where,

		<u>Units</u>
$C_{seq_{MM}}$	= Total carbon sequestration from mountain meadow restoration	MT CO <sub>2</sub> e
95.40	= Annual carbon sequestered in restored mountain meadows, 50 Year timescale	$\frac{\text{g C}}{\text{m}^2 \text{ Year}}$
$A_{MM}$	= Area of land restored to mountain meadows	Acres
4046.86	= Conversion from square meters to acres	$\frac{\text{m}^2}{\text{Acres}}$
1,000,000	= Conversion from grams to metric tons	$\frac{\text{g}}{\text{MT}}$
$\frac{44}{12}$	= Molecular Weight Ratio of carbon dioxide to carbon	$\frac{\text{MT CO}_2\text{e}}{\text{MT C}}$
50	= Number of years of project life	Years