WR Methodological Module

Estimation of baseline carbon stock changes from Wetland Restoration including projected wetland loss in the baseline scenario (BL-WR-WL)

I. SCOPE, APPLICABILITY AND PARAMETERS

Scope

This module allows for estimating carbon stock changes related to Wetland Restoration (WR) when the baseline includes projected wetland loss that would result in a reduction of the wetland project area in the baseline scenario. Implementing a wetland restoration activity not only enhances vegetative productivity and carbon sequestration, but also may prevent further wetland loss. This module accounts for baseline sequestration that would decrease over time as wetlands degrade and convert into open water. This module ~~conservatively does not~~also accounts for the fate and transport of carbon during wetland loss that may result in emissions due to oxidation of soil organic carbon.

Applicability

The module is applicable for estimating baseline carbon stock changes and GHG emissions related to wetland restoration through assisted natural regeneration, seeding, or tree planting. The following conditions must be met to apply this module.

- Project activities meet the applicability conditions in the WR-MF listed under All Activity Types.
- The project does not alter the current hydrology or water management practices such that the project could impact GHG emissions.

Parameters

This module provides procedures to determine the following parameter:

Parameter	SI Unit	Description
$\Delta C_{bsl,WR\text{-}WL}$	t CO_2-e	Cumulative total carbon stock changes and greenhouse gas emissions for the baseline scenario including projected wetland loss that would result in a reduction of the wetland project area.
$\Delta C_{TREE\_BSL\_loss}$	t CO_2-e	Cumulative total carbon stock changes of living tree biomass for the baseline scenario including wetland loss that would result in a reduction of the wetland project area and a loss of sequestration capacity in the absence of project implementation
$\Delta C_{SOC\_BSL\_loss}$	t CO_2-e	Cumulative total carbon stock changes of soils for the baseline scenario including wetland loss that would result in a reduction of the wetland project area in the absence of project implementation

II. PROCEDURE

This module proceeds in five steps:

- Step 1. Identification of baseline scenario
- Step 2. Project boundary
- Step 3. Baseline stratification
- Step 4. Baseline net GHG removals for fixed baselines
- Step 5. Monitoring requirements for baseline renewal

Step 1. Identification of the baseline scenario

Baseline determination is defined from Paragraph 22 of the CDM A/R Modalities and Procedures as "existing or historical, as applicable, changes in carbon stocks in the carbon pools within the project boundary" where the land would remain degraded in the absence of the project activity. Project Proponent must demonstrate that the land would remain degraded in the absence of the project activity by applying the tool T-DEG. This may be accomplished by using multiple sources of data, such as from peer-reviewed literature, archives, maps or satellite images of the land use/cover prior to project activity, field surveys, governmental

reports, expert judgment[1] and interviews with land owners or professionals affiliated with wetland management of the area. Project Proponent must demonstrate that the candidate baseline scenario does not alter historical wetland patterns by analyzing the historical and existing wetland over the most recent 10-year period prior to the project start date, or longer if necessary, to demonstrate baseline historical wetland patterns.

Step 2. Project boundary

The project boundary geographically delineates the WR project activity under the control of the Project Proponent (PP) as defined in the WR-MF. It shall be demonstrated that each discrete parcel of land to be included in the boundary is eligible for a WR ACR project activity.

The pools that will be included or excluded from accounting are provided in WR-MF. WR-MF shall be followed in determining the GHG assessment boundary, along with the guidance in the ACR *Forest Carbon Project Standard,* Chapter 2. Since the project does not alter the current hydrology or water management practices such that the project could impact GHG emissions, it is conservative to exclude emission sources from the assessment boundary and from accounting in the baseline and project scenario.

Step 3. Baseline stratification

Stratification is a standard statistical procedure to decrease overall variability of carbon stock estimates by grouping data taken from environments with similar characteristics. When estimating baseline carbon stocks, several strata can be assessed, including but not limited to:

a. Management regime
b. Vegetation type and species
c. Age class
d. Trend in land loss conversion
e. Water quality (e.g. salinity, nutrient inputs, distance from source, etc.)
f. Hydrology
g. Elevation and subsidence rates
h. Site index and anticipated growth rates
i. Areas prone towards wetland loss

If the project activity area is not homogeneous, stratification should be carried out to improve the accuracy and precision of carbon stock estimates. Different stratifications may be required for the baseline and project scenarios, in order to achieve optimal accuracy and precision of the estimates of net GHG removal by sinks. For estimation of baseline net GHG removals by sinks, or estimation of actual net GHG removals by sinks, strata should be defined based on parameters that affect GHG removals and/or that are key entry variables for the methods used

[1] Justification should be supplied for all values derived from expert judgment.

to measure changes in biomass stocks.

- **For baseline net GHG removals by sinks,** it will usually be sufficient to stratify according to major vegetation types since baseline removals for degraded (or degrading) wetlands can be expected to be small in comparison to project removals;
- **For actual net GHG removals by sinks**, the stratification for *ex-ante* estimations shall be based on the project monitoring plan. The stratification for *ex-post* estimations shall be based on the actual implementation of the project monitoring plan. If natural or anthropogenic impacts (e.g., hurricanes) or other factors add variability to the growth pattern of the project area, then the *ex-post* stratification shall be revised accordingly.

Project Proponent may use remotely sensed data acquired close to the time of project commencement and/or the occurrence of natural or anthropogenic impacts for *ex-ante* and *ex-post* stratification.

Step 4. Baseline net removals for fixed baselines

The WR wetland baseline scenario is the carbon stock present immediately prior to site preparation or the most likely carbon stock in the absence of project implementation. Therefore, the baseline net GHG removals by sinks is the sum of the changes in carbon stocks in the selected carbon pools within the project boundary just prior to site preparation, or that would have occurred in the absence of the project activity. The baseline scenario carbon storage rates can be determined by examining appropriate reference sites if activities have already begun. The Project Proponent must retain a conservative approach in making these estimates.

Under the applicability conditions of this methodology:

- Changes in the carbon stock of aboveground biomass of non-tree vegetation may be conservatively assumed to be zero for all strata in the baseline scenario;
- Changes in the carbon stock of dead wood and litter/surface debris carbon pools are conservatively omitted. Therefore, the sum of the changes in the carbon stocks of dead wood and litter carbon pools is zero for all strata in the baseline scenario.

The baseline net GHG removals by sinks shall be estimated using the equations in this section. When applying these equations for the *ex-ante* calculation of baseline net GHG removals by sinks, Project Proponent shall provide estimates of the values of those parameters that are not available before the start of the Crediting Period and commencement of monitoring activities. Project Proponent should retain a conservative approach in making these estimates.

4.1 Baseline carbon stocks[2]

The net carbon stock changes in the baseline are equal to the baseline living tree biomass stock plus the soil organic carbon stock that includes projected wetland loss (a reduction in wetland project area that would occur in the baseline scenario). The baseline net GHG removals by sinks will be determined as:

$$\Delta C_{bsl,WR\text{-}WL} = \Delta\cancel{\Delta} C_{TREE\_BSL\_loss} + \Delta C_{SOC\_BSL\_loss} \quad (1)$$

where:

$\Delta C_{bsl\text{-}WR\text{-}WL}$ Cumulative total of the carbon stock changes for the baseline scenario up to time *t*; t CO_2-e

$\Delta C_{TREE\_BSL\_loss}$ Cumulative total of the carbon stock changes of living tree biomass for the baseline scenario including wetland loss up to time *t*; t CO_2-e

$\Delta C_{SOC\_BSL\_loss}$ Cumulative total of the carbon stock changes of soils for the baseline scenario including wetland loss; a reduction in wetland project area that would occur in the absence of project implementation up to time *t*; t CO_2-e

For calculation of carbon stock sequestered in living tree biomass see the module "Estimation of carbon stocks in tree biomass" (CP-TB).

Rate of Wetland Loss

This module requires knowledge of the rate at which the project area wetlands would be lost through the project period (i.e., area of wetland loss per year) without project implementation. The baseline wetland loss in hectares per year in the project boundary must be determined before the start of the project activity, but can be modified during the course of the project if relevant data becomes available. Project Proponent must make conservative estimates.

In the ideal scenario, the factors of wetland loss are already defined and the site has specific sources of data, such as from peer-reviewed literature, archives, maps or satellite images of the land use/cover prior to project activity, field surveys, and governmental reports to provide a justified rate of wetland loss.

If no verified rate exists, the rate can be established by examining proxy areas. Examination of proxy areas may be through original data collection (field measurements and/or remote sensing analysis) or where appropriate, use of directly applicable existing data generated from credible sources.

[2] Stock estimates shall occur for the pools defined through the framework module WR-MF

The following criteria for applicability of proxy areas to determine wetland loss rates must be met:

a. **The main factor(s) of wetland loss** in the proxy at the start of the historical reference period must be the same as those expected to cause wetland loss in the project area during the project term. The historical reference period is defined as the historical period prior to the project Start Date that serves as the source of data for defining the baseline. Examples of factors include:

- Flood control levees/ elimination of riverine inputs
- Impoundment
- Reduced sediment load
- Salinity intrusion
- Subsidence / Relative Sea Level Rise (RSLR)
- Lack of freshwater
- Lack of nutrient inputs

b. **Policies, regulations, and programs** adopted at the national or regional level must influence the proxy area in the same way, or have an equivalent effect at the start of the historical reference period, taking into effect the current level of enforcement and program implementation (restoration programs).

c. **Transportation networks and human infrastructure,** such as navigable rivers and canals, that increase the likelihood of wetland loss and that exist historically in the proxy area must be directly comparable to those that are expected to exist within the project area during the project term.

d. **Wetland management** in the proxy area will be the same as in the project area under business as usual.

4.2 Baseline carbon stock changes of the living tree biomass pool during wetland loss ($\Delta C_{TREE\_BSL\_loss}$)

Project Proponent may conservatively quantify carbon stock changes of living tree biomass including projected wetland loss (a reduction in wetland project area) for the baseline scenario. See the module "Estimation of Carbon Stocks in Tree Biomass" (CP-TB) for calculation of carbon stock in living trees. The estimation of carbon stock changes of living trees for the baseline scenario (ΔC_{TREE_BSL}) from CP-TB will be modified to ($\Delta C_{TREE\_BSL\_loss}$) using the equation below. If there is more than one stratum in the baseline scenario, the outcome should be summed over

all the strata to obtain the value for the whole project.

$$\Delta C_{TREE\_BSL\_loss} = \sum_{y=1}^{t} (H_y/H_o) * \frac{\Delta C_{TREE\_BSL}}{t} \quad (2)$$

where:

$\Delta C_{TREE\_BSL\_loss}$	Cumulative total of the carbon stock changes of living tree biomass for the baseline scenario including wetland loss; a reduction in wetland project area that would occur in the absence of project implementation up to time *t*; t CO_2-e
ΔC_{TREE_BSL}	Cumulative total of the carbon stock changes of living tree biomass for the baseline scenario up to time *t*; t CO_2-e (CP-TB)
H_y	Wetland project area at year y; ha
H_o	Wetland project area at t=0; ha
y	1, 2, 3, 4…. time to monitoring event t; years
t	year of monitoring event; years

4.~~3~~2 Baseline carbon stock changes in soil pool including wetland loss ($\Delta C_{SOC\_BSL\_loss}$)

Project Proponent may conservatively quantify carbon stock changes ~~in~~ of the soil pool including projected wetland loss (a reduction in wetland project area) ~~in~~ for the baseline scenario. For calculation of carbon stock sequestered in soils see the Module "Estimation of ~~carbon~~ Carbon ~~stocks~~ Stocks in the ~~soil~~ Soil ~~organic~~ Organic ~~carbon~~ Carbon ~~pool~~Pool" (CP-S) for calculation of carbon stock sequestered in soils. The estimation of carbon stock changes ~~in~~ of the soil in the baseline scenario (ΔC_{SOC_BSL}) from CP-S will be modified to ($\Delta C_{SOC\_BSL\_loss}$) using the equation~~s~~ below. These equations provide for the calculations to be performed for each stratum. If there is more than one stratum in the baseline scenario, the outcome ~~will~~ should be summed over all the strata to obtain the value for the whole project.

$$\Delta C_{SOC\_BSL\_loss} = \sum_{y=1}^{t} (H_y/H_o) * f\,C_{SOC\_BSL} \quad (3)$$

where:

$\Delta C_{SOC\_BSL\_loss}$	Cumulative total of the carbon stock changes of soils for the baseline scenario including wetland loss; a reduction in wetland project area that would occur in the absence of project implementation up to time *t*; t CO_2-e

$f\,C_{SOC\_BSL}$	Rate of increase in soil carbon stock for the baseline scenario; t CO2-e yr^{-1} (CP-S)
H_y	Wetland project area at year y; ha
H_o	Wetland project area at t=0; ha
y	1, 2, 3, 4…. time to monitoring event t; years
t	year of monitoring event; years

4.4 Baseline emissions during wetland loss and from the decomposition of organic matter during wetland loss ($\Delta GHG_{F\_BSL\_loss}$)

Currently, little peer-reviewed data ~~insufficient knowledge~~ exists regarding the fate and transport of carbon during wetland loss. Further ~~Critical~~ research is needed to determine what proportion of the soil horizon, or at what rate, this material is decomposed and results in CO_2 and CH_4 emissions. If project proponents choose to quantify the projected emissions that would occur due to wetland loss in the baseline scenario, ~~and are able to sufficiently address the fate and transport of carbon during wetland loss,~~ the equations below can be applied in lieu of equation C3.5.1 in module E-E. Project Proponents may use peer-reviewed literature and must make conservative estimates. Project proponents must ~~are required to~~ provide supporting evidence and justification ~~arguments~~ supporting the emission values used. Expert judgment and statements by professionals affiliated with wetland management may be provided as part of the supporting evidence. If the rate of wetland loss is known, but the proportion or rate of soil organic carbon released as GHGs from wetland decomposition is not, SOC_{50cm} can be conservatively set to zero:

If the annual proportion of soil organic carbon released as GHGs is known, the following equation can be used:

$$\Delta GHG_{E\_BSL\_loss} = \sum_{y=1}^{t} \left((H_y/H_o) * \Delta GHG_{E\_BSL} + H_y * SOC_{50cm} * (\%_{CO2} + \%_{CH4} * GWP_{CH4} + \%_{N2O} * GWP_{N2O}) \right) \quad (4)$$

where:

$\Delta GHG_{F\_BSL\_loss}$	Cumulative total GHG emissions from the project area for the baseline scenario including wetland loss, and GHG emissions resulting from decomposition of organic matter during wetland loss up to time *t*; t CO_2-e yr^{-1}
ΔGHG_{F_BSL}	Annual total GHG emissions from the project area for the baseline scenario (equation (1) of module E-E with *T*=1); t CO_2-e yr^{-1}
H_y	Wetland project area at year y; ha

H_0 Wetland project area at t=0; ha

y 1, 2, 3, 4…. time to monitoring event t; years

t year of monitoring event; years

SOC_{50cm} Amount of carbon in top 50 cm of wetland soil profile; t CO2-e ha^{-1} (CP-S)

$\%_{CO2}$ Proportion of soil organic carbon released as CO_2 emissions per year (0-1); no units

$\%_{CH4}$ Proportion of soil organic carbon released as CH_4 emissions per year (0-1); no units

GWP_{CH4} Global warming potential for CH_4 (= 21 for the first commitment period); t CO_2-e (t CH_4)$^{-1}$

$\%_{N2O}$ Proportion of soil organic carbon released as N_2O emissions per year (0-1); no units

GWP_{N20} Global warming potential for N_2O (= 310 for the first commitment period); t CO_2-e (t N_2O)$^{-1}$

Alternatively, the following equation can be used if the annual rates of emissions of GHGs during wetland loss are known:

$$\Delta GHG_{E\_BSL\_loss} = \sum_{y=1}^{t} \left((H_y/H_o) * \Delta GHG_{E\_BSL} + H_y * (f\,GHG_{CO2\_loss} + f\,GHG_{CH4\_loss} * GWP_{CH4} + f\,GHG_{N2O\_loss} * GWP_{N2O}) \right) \quad (5)$$

where:

$\Delta GHG_{E\_BSL\_loss}$ Cumulative total GHG emissions from the project area for the baseline scenario including wetland loss, and GHG emissions resulting from decomposition of organic matter during wetland loss up to time t; t CO_2-e yr^{-1}

ΔGHG_{E_BSL} Cumulative total GHG emissions from the project area for the baseline scenario (equation (1) of module E-E with T=1); ton CO_2-e yr^{-1}

$f\,GHG_{CO2\_loss}$ Rate of CO_2 emissions during wetland loss; t C ha^{-1} yr^{-1}

$f\,GHG_{CH4\_loss}$ Rate of CH_4 emissions during wetland loss; t C ha^{-1} yr^{-1}

$f\,GHG_{N2O\_loss}$ Rate of N_2O emissions during wetland loss; t C ha^{-1} yr^{-1}

~~$\Delta C_{SOC\_BSL\_loss} = (H_g/H_o) * \Delta C_{SOC\_BSL}$ (2)~~

~~where:~~

~~$\Delta C_{SOC\_BSL\_loss}$ Cumulative total of the carbon stock changes of soils for the baseline scenario including wetland loss; a reduction in wetland project area that would occur in the absence of project implementation up to time t; t CO_2-e yr^{-1}~~

~~ΔC_{SOC_BSL} Cumulative total of the carbon stock changes of soils in the baseline scenario up~~

~~to time *t*; t CO_2-e yr^{-1} (CP-S)~~

~~$H_t = H_o - h*t$ (3)~~

~~where:~~

~~H_t Wetland project area at time t; ha~~

~~H_o Wetland project area at time t=0; ha~~

~~h Baseline land loss per year, or the reduction in wetland project area within the project boundary projected over the life of the project in the absence of project implementation; ha yr^{-1}~~

~~t time after project initiation; yr[3]~~

~~Rate of wetland loss (h)~~

~~This module requires knowledge of the rate (area of wetland loss per year) at which the project area wetlands would be lost to give an area per stratum (*i*) per year (*t*) through the project period. The baseline wetland loss in hectares per year in the project boundary must be determined before the start of the project activity. Project Proponent must make conservative estimates.~~

~~In the simplest scenario the factors of wetland loss are already defined and the site has specific sources of data, such as from peer-reviewed literature, archives, maps or satellite images of the land use/cover prior to project activity, field surveys, and governmental reports of the area to provide a justified rate of wetland loss.~~

~~If no verified rate exists, the rate will be established by examining proxy areas. The proxy area will be used to estimate an average proportion of wetlands that is lost each year, thus a sufficient number of parcels are needed to be representative of the wetland loss factors in the proxy area, and hence also in the project area. Examination of proxy areas may be through original data collection (field measurements and/or remote sensing analysis) or where appropriate use of directly applicable existing data generated from credible sources.~~

~~The following criteria for applicability of proxy areas to determine wetland loss rates must be met:~~

a. ~~**The main factor(s) of wetland loss** in the proxy at the start of the historical reference period must be the same as those expected to cause wetland loss in the project area during the project term. The historical reference period is defined as the historical period prior to the project Start Date that serves as the source of data for defining the baseline. Examples of factors include:~~

~~[3] t cannot be longer than the H_o divided by h at which time the entire project area will have converted to open water.~~

- Flood control levees / elimination of riverine inputs
- Impoundment
- Reduced sediment load
- Salinity intrusion
- Subsidence / Relative Sea Level Rise (RSLR)
- Lack of freshwater
- Lack of nutrient inputs

b. **Policies, regulations, and programs** adopted at the national or regional level must influence the proxy area in the same way, or have an equivalent effect at the start of the historical reference period, taking into effect the current level of enforcement and program implementation (restoration programs).

c. **Transportation networks and human infrastructure,** such as navigable rivers and canals, that increase the likelihood of wetland loss and that exist historically in the proxy area must be directly comparable to those that are expected to exist within the project area during the crediting period.

d. **Wetland management** in the proxy area will be the same as in the project area under business as usual. The proxy area shall have the same proportions of wetland types as in the project area (+/- 20%).

When using proxy areas to determine baseline wetland loss the following equation may be used:

$$\Delta C_{SOC\_BSL\_loss} = h_{i,t} * \Delta C_{SOC\_BSL} \quad (4)$$

where:

$\Delta C_{SOC\_BSL\_loss}$ Cumulative total of the carbon stock changes of soils in the baseline scenario including wetland loss that would occur in the absence of project implementation up to time *t;* t CO_2-e

ΔC_{SOC_BSL} Cumulative total of the carbon stock changes of soils in the baseline scenario up to time *t;* t CO_2-e (CP-S)

$h_{i,t}$ Projected annual proportion of wetland that will be lost in stratum *i* during year *t;* %

If actual annual proportion of wetland that will be lost is known and documented, e.g. 25% per year for 4 years, then set $h_{i,t}$ to this proportion. Alternately if estimating the rate of wetland loss from a proxy area, set

$$h_{i,t} = \left(\sum_{pn=1}^{n^*} (h\%_{pn} / Yrs_{pn})\right)/n$$

~~(5)~~

~~where:~~

~~$h_{i,t}$ Projected annual proportion of wetland that will be lost in stratum *i* during year *t*; %~~

~~$h\%_{pn}$ Percent of wetland loss in land parcel[4] *pn* etc of a proxy area as a result of wetland loss factors identified in this module; %~~

~~Yrs_{pn} Number of years over which wetland loss occurred in land parcel *pn* in proxy area; years~~

~~*n* Total number of land parcels examined~~

~~*pn* 1,2,3,…n* land parcels examined in proxy area~~

~~*i* 1,2,3,…M strata~~

Step 5. Monitoring requirements for baseline renewal

A Crediting Period for a project is a predetermined length of time for which the baseline scenario is applicable. This period of time is used for carbon quantification of offsets generated relative to its baseline.

In order to renew the Crediting Periods the Project Proponent must:[5]

- Re-submit the GHG Project Plan in compliance with then-current GHG Program standards and criteria;
- Re-evaluate the project baseline;
- Demonstrate additionality against then-current regulations and performance standard data;
- Use GHG program-approved baseline methods, emission factors, tools, and methodologies in effect at the time of Crediting Period renewal;
- Undergo validation by an approved validation/verification body.

~~[4] Parcels are a unit of land area. A stratum may contain many parcels.~~

[5] American Carbon Registry, 2010. American Carbon Registry Forest Carbon Project Standard, version 2.1. Winrock International, Little Rock, Arkansas. http://www.americancarbonregistry.org/carbon-accounting/forest-carbon-project-standard-v2.0. Last Accessed: June 6, 2010. 63 pages.

DATA AND PARAMETERS NOT MONITORED

Data /parameter:	H_0~~h~~
Data unit:	ha ~~year^{-1}~~
Used in equations:	2, 3
Description:	Wetland project area at the start of the project (t=0)~~Baseline land loss per year in the project boundary projected over the life of the project in the absence of project implementation~~
Source of data:	Peer-reviewed literature, archives, maps or satellite images of the land use/cover prior to project activity, field surveys, and governmental reports.
Measurement procedures (if any):	N/A
Any comment:	Determined at start of project.

Data /parameter:	H_y~~$h_{i,t}$~~
Data unit:	ha~~% year^{-1}~~
Used in equations:	2, 3~~4, 5~~
Description:	Wetland project area at monitoring event t ~~Projected annual proportion of wetland that will be lost in stratum *i* during year *t*~~
Source of data:	Peer-reviewed literature, archives, maps or satellite images of the land use/cover prior to project activity, field surveys, and governmental reports.~~Analysis of remote sensing data and/or peer-reviewed literature, archives, maps or satellite images of the land use/cover prior to project activity, field surveys, governmental reports, expert judgment for a number of proxy areas~~
Measurement procedures (if any):	N/A
Any comment:	Shall be revisited at the time of baseline renewal

PARAMETERS ORIGINATING IN OTHER MODULES

Data /parameter:	ΔC_{TREE_BSL}
Data unit:	t CO_2-e
Used in equations:	~~1~~2
Description:	Cumulative total of the carbon stock changes of living tree biomass in the baseline scenario up to time *t*

Module parameter originates in:	CP-TB
Any comment:	

Data /parameter:	$f\ C_{SOC\_BSL}$ ~~ΔC_{SOC_BSL}~~
Data unit:	t CO_2-e yr^{-1}
Used in equations:	~~2, 4~~3
Description:	Rate of increase in soil carbon stock for the baseline scenario ~~Cumulative total of the carbon stock changes of soils for the baseline scenario~~
Module parameter originates in:	CP-S
Any comment:	