Gold Standard for the Global Goals

Climate Security & Sustainable Development

METHODOLOGY TOOL

GS4GG PAA 400 MT 004

SDG 13

REVERSAL RISK CALCULATIONS FOR GEOLOGICAL STORAGE

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SUMMARY

This Methodology Tool 4 (herein referred to as Tool 4) provides a reversal risk assessment for activities which inject carbon dioxide (CO_2) as a gas, supercritical fluid, dissolved in water, or in a liquid state into saline aquifers or depleted hydrocarbon reservoirs. Tool 4 converts the risk assessment into a Reversal Risk Rating, which shall be used by activity developers to transfer Gold Standard Verified Emissions Reductions (GS-VERs) to the Gold Standard Compliance Buffer proportionally to ensure that all issued GS-VERs remain valid despite potential reversals. Tool 4 shall be applied in conjunction with the Gold Standard for the Global Goals (GS4GG)-approved methodology for Biomass Fermentation with Carbon Capture and Geologic Storage. It is not applicable to active hydrocarbon reservoirs, or reservoirs located under marine environments, or reservoirs where the Area of Review crosses international boundaries.

ACKNOWLEDGEMENTS

SUMMIT CARBON SOLUTIONS

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1| KEY INFORMATION

Item	Description
Tool summary	Tool 4 provides a qualitative reversal risk assessment for activities which inject CO_2 as a gas, supercritical fluid, dissolved in water, or in a liquid state into saline aquifers or depleted hydrocarbon reservoirs. Tool 4 converts the risk assessment into a Reversal Risk Rating, which shall be used by activity developers to transfer GS-VERs to the Gold Standard Compliance Buffer proportionally to ensure that all issued GS-VERs remain valid despite potential reversals.
Applicable mitigation type	☐ Emission reductions ☒ Removals
Applicable activity scale	☒ Micro scale (e.g., ≤10,000 tCO_2e per year) ☒ Small scale (e.g., ≤60,000 tCO_2e per year) ☒ Large scale (e.g., >60,000 tCO_2e per year)
Applicable methodologies	Biomass Fermentation with Carbon Capture and Geologic Storage
Limitations	Tool 4 is applicable only to activities which inject CO_2 as a gas, supercritical fluid, dissolved in water, or in a liquid state into saline aquifers or depleted hydrocarbon reservoirs. Active hydrocarbon reservoirs, or reservoirs located under marine environments, or reservoirs where the Area of Review crosses international boundaries are not eligible.

2| APPLICABILITY CONDITIONS

2.1.1 | Tool 4 shall be used in conjunction with the GS4GG methodology for Biomass Fermentation with Carbon Capture and Geologic Storage.

2.1.2 | Tool 4 is applicable only to activities which inject CO_2 as a gas, supercritical fluid, dissolved in water, or in a liquid state into saline aquifers or depleted hydrocarbon reservoirs.

3| NORMATIVE REFERENCES

3.1.1 | Tool 4 refers to the following methodologies, tools, and documents:

a. GS4GG:
   i. Principles & Requirements
   ii. Safeguarding Principles & Requirements
   iii. Biomass Fermentation with Carbon Capture and Geologic Storage
   iv. Engineered Removals Activity Requirement

v. Methodology Tool 3: Emissions and Monitoring Requirements for Geological Storage

b. Other Sources:

i. Energy & Environmental Research Center (EERC), University of North Dakota – Quantifying the Potential Atmospheric Leakage Risks Associated with the Geologic Storage of CO_2 in Saline Aquifers (2024).

4| DEFINITIONS

4.1.1 | The definitions outlined in the GS4GG Glossary shall apply in addition to those outlined below.

5| SCOPE AND BOUNDARY

5.1 | Activity Scope

5.1.1 | Activities which involve geological storage may be at risk of reversal, i.e., a (re)release of CO_2 from the geological storage site into the atmosphere. This risk of reversal shall be compensated by the activity developer via the transfer of GS-VERs to the Gold Standard Compliance Buffer using the Reversal Risk Rating determined by the calculations outlined in Tool 4.

5.2 | Activity Boundary

5.2.1 | The activity boundary shall be specified in the applied methodology.

6| SAFEGUARDS

6.1.1 | The activity shall adhere to the Gold Standard Principles & Requirements and Safeguarding Principles & Requirements as well as those outlined in the applied methodology.

7| COMPLIANCE BUFFER

7.1 | Scope

7.1.1 | Activities which involve geological storage may be at risk of reversal, i.e., a (re)release of CO_2 from the geological storage site into the atmosphere.

7.1.2 | The risk of reversal shall be compensated by the activity developer via the transfer of GS-VERs to the Gold Standard Compliance Buffer.

7.2 | Contribution to the Compliance Buffer

7.2.1 | The number of GS-VERs that need to be transferred to the Gold Standard Compliance Buffer shall be proportional to the Reversal Risk Rating, $RRR_{project,y}$, of the activity and shall be calculated as follows:

$$BufferTransfer_y = BE_y \times RRR_{project,y}$$

Where:

$BufferTransfer_y$	=	Quantity of GS-VERs to be transferred by the activity developer to the Gold Standard Compliance Buffer in year y (tCO_2e)
BE_y	=	Baseline emissions from the injection of CO_2 activity in year y (GSVERs)
$RRR_{project,y}$	=	Reversal risk rating of the activity in year y (%)

7.2.2 | If the calculated Reversal Risk Rating is <2.5, a default value of 2.5% shall be applied to the buffer contribution calculations in order to be conservative.

7.2.3 | Activity developers shall determine the quantity of GS-VERs to be transferred to the Gold Standard Compliance Buffer at each verification stage and shall report these quantities in the activity monitoring report.

7.2.4 | Subject to approval by Gold Standard on a case-by-case basis, activity developers may be permitted to transfer GS-VERs from other Gold Standard–certified activities to the Compliance Buffer in lieu of the GS-VERs from the activity.

7.3 | Use of the Compliance Buffer

7.3.1 | If a reversal occurs during the crediting period, it shall be considered as a performance shortfall, and the criteria outlined in the Performance Shortfall Guidelines, Requirements, and Procedure shall be followed accordingly.

7.3.2 | If a reversal occurs after the crediting period has ended, GS-VERs held in the Gold Standard Compliance Buffer shall be cancelled as necessary to compensate for the tCO_2e lost.

8| REVERSAL RISK RATING

8.1 | Overall Risk Rating

8.1.1 | The Reversal Risk Rating, $\mathrm{RRR}_{\text{storage site}_{s,y}}$, shall be a value between **1** and **8.5** and shall be calculated as follows:

$$\mathrm{RRR}_{\text{storage site}_{s,y}} = \mathrm{Risk}_{\mathrm{Base}_{s,y}} + \mathrm{Risk}_{\mathrm{Closure}_{s,y}} + \mathrm{Risk}_{\mathrm{Regulatory}_{s,y}}$$

Where:

$\mathrm{RRR}_{\text{storage site}_{s,y}}$	=	Overall reversal risk rating for storage site s in monitoring period y
$\mathrm{Risk}_{\mathrm{Base}_{s,y}}$	=	Base storage risk for storage site s in monitoring period y
$\mathrm{Risk}_{\mathrm{Closure}_{s,y}}$	=	Closure risk for storage site s in monitoring period y
$\mathrm{Risk}_{\mathrm{Regulatory}_{s,y}}$	=	Regulatory risk for storage site s in monitoring period y

8.1.2 | The maximum Reversal Risk Rating for any applicable storage shall be the Reversal Risk Rating of the activity:

$$\mathrm{RRR}_{\mathrm{activity}_y} = \max_{s}\left(\mathrm{RRR}_{\text{storage site}_{s,y}}\right)$$

8.1.3 | If the calculated Reversal Risk Rating is >6.7, the activity shall not be eligible for Gold Standard certification.

8.2 | Base Storage Risk

8.2.1 | The Base Risk, $\text{Risk}_{\text{Base}_{s,y}}$, represents the risk of cumulative CO_2 losses to the atmosphere through natural and artificial leakage pathways from a storage site with adequate regulatory oversight.

8.2.2 | The $\text{Risk}_{\text{Base}_{s,y}}$ shall be determined based on the CO_2 plume area-to-mass ratio (defined in units of $\frac{\text{mile}^2}{\text{million tonnes CO}_2}$), $Ratio_{CO_2\ plume\ area-to-mass_{s,y}}$, which is defined as the ratio of:

a. the two-dimensional ground surface area (in square miles or similar) that is bounded by the Area of Review of the storage site, and
b. the maximum injection capacity of the storage site (in metric million tonnes of CO_2 or similar), as stipulated in the authorizations to construct or operate the storage site.

8.2.3 | For eligible activities, $\text{Risk}_{\text{Base}_{s,y}}$ shall be scored as follows:

Risk Criteria	Risk Score
$Ratio_{CO_2\ plume\ area-to-mass_{s,y}} \leq 1$	1
$Ratio_{CO_2\ plume\ area-to-mass_{s,y}} > 1$	2.5

8.3 | Closure Risk

8.3.1 | The Closure Risk, $Risk_{Closure}$, represents the risk of the storage site operator's inability to undertake closure activities and is assessed based on the type and amount of funds dedicated to closure activities.

8.3.2 | Qualified funds are any dedicated financial responsibility instrument whereby:

a. "Dedicated" means that the financial responsibility instrument cannot be used or drawn on for purposes other than the closure activities provided in the closure plan or secured as collateral by creditors of the beneficiaries or recipients of the financial responsibility instrument.
b. Financial responsibility instruments include trust funds, surety bonds, letters of credit, third-party insurance, and funds in escrow. Activity developers shall provide evidence substantiating the ability of counterparties to meet the obligations of the financial responsibility instrument.
c. Financial responsibility instruments may also serve to fulfil financial assurance demonstrations required by regulators, provided those

instruments are dedicated to the same activities.[1] For avoidance of doubt, contributions made to funds managed by the government or regulators and for the benefit of publicly held and/or orphaned liabilities (e.g., Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] superfund program[2]) are not financial responsibility instruments.

8.3.3 | Activity developers shall provide evidence of qualified funds and determine $\text{Risk}_{\text{Closure}_{s,y}}$ in accordance with Methodology Tool 3.

8.3.4 | Activities involving storage sites are ineligible to receive GS-VERs when any of the following apply:

a. No evidence of qualified funds is provided.
b. All financial responsibility instruments evidenced do not meet the requirements for qualified funds provided in Methodology Tool 3.
c. The evidence of qualified funds for closure activities are provided, and those qualified funds do not meet or exceed 5% of the estimated costs of storage site closure activities as provided in the closure plan per Methodology Tool 3.

8.3.5 | For eligible activities, $\text{Risk}_{\text{Closure}_{s,y}}$ shall be scored as follows:

Risk Criteria	Risk Score
$\frac{\text{Qualified Funds}_{s,y}}{\text{Closure Activity Costs}_{s,y}} \geq 0.95$	0
$0.05 < \frac{\text{Qualified Funds}_{s,y}}{\text{Closure Activity Costs}_{s,y}} < 0.95$	$\frac{3}{1+e^{-3\times\left(1-2\times\left(\frac{\text{Qualified Funds}_{s,y}}{\text{Closure Activity Costs}_{s,y}}\right)\right)}}$

8.3.6 | See Annex 1 for further information regarding the calculation of $\text{Risk}_{\text{Closure}_{s,y}}$.

8.4 | Regulatory Risk

8.4.1 | The Regulatory Risk, $\text{Risk}_{\text{Regulatory}_{s,y}}$, represents the risk associated with the storage site regulator's inability to effectively implement, administer, and enforce regulations.

8.4.2 | Activity developers shall assess $\text{Risk}_{\text{Regulatory}_{s,y}}$ based on a selection of Worldwide Governance Indicators (WGI) developed and published by the

[1] For example, a surety bond guaranteeing performance of injection well plugging and abandonment may count towards both qualified dedicated funds and regulatory financial assurance demonstrations.

[2] U.S. Code, Chapter 103 of Title (42 U.S.C. 103)

World bank.[3] The indicators that are relevant to the assessment of durable geologic storage are Government Effectiveness (GE), Rule of Law (RL), and Control of Corruption (CC).

8.4.3 | Activity developers shall determine a composite score for the country or territory in which the storage site is located, calculated as the mean of the values published for GE, RL, and CC for the most recent five years (the required values are provided in absolute terms ranging from -2.5 to 2.5 rather than percentiles).

a. Activities located in countries which lack any of the requisite WGI for any of the most recent five years or which have a composite score of less than -1 are ineligible to receive GS-VERs.

8.4.4 | For eligible activities, $\text{Risk}_{\text{Regulatory}_{s,y}}$ shall be scored as follows:

Risk Criteria	Risk Score
$Score_{Composite_{s,y}} \geq 1$	0
$0 \leq Score_{Composite_{s,y}} < 1$	1
$-1 \leq Score_{Composite_{s,y}} < 0$	3

[3] Kaufmann, D., Aart K., and Massimo M. (2023), World Bank, Worldwide Governance Indicators, http://info.worldbank.org/governance/wgi

ANNEX 1

Derivation of the Closure Risk Equation

The Closure Risk, $Risk_{Closure}$, represents the risk of the storage site operator's inability to undertake closure activities and is assessed based on the type and amount of funds dedicated to closure activities. The equation provided in Section 8.3.5 gives the logistic model for the $Risk_{Closure}$, wherein marginal increases in qualified funding for closure activities yield diminishing decreases in closure risk score, as shown in Figure 1.

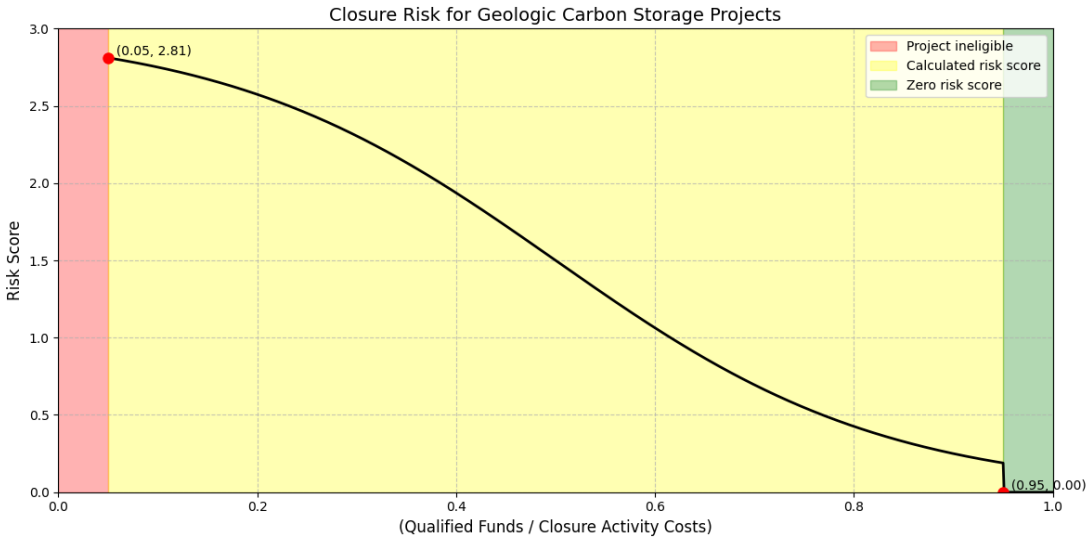

Figure 1. Diagram illustrating the logistic function for the derivation of the risk score based on the value of qualified funds/closure activity costs

The dedicated funds function similarly to a down payment for a mortgage, which acts as security to the lender against adverse events to the borrower's ability to service debt. In the case of storage activities, adverse events during closure are of low probability but have the potential to be high impact if unmitigated (e.g., a well blowout due to operator insolvency). Qualified funding ensures that, if the adverse effects do materialise, they can be mitigated.

The logistic function (yellow section in Figure 1) describes $Risk_{Closure}$ as a function of the funds dedicated to closure activities. This logistic function describes the cumulative impact of lognormal distributions. The results of EERC's modelling (see Figure 1 in the referenced document) indicates that leakage of CO_2 into the atmosphere from a geologic storage activity is described by a lognormal statistical distribution. Further, the sensitivity analysis conducted by EERC indicates that the most important input parameters are also described by lognormal statistical distributions. These facts support a hypothesis that the impact of factors underlying $Risk_{Closure}$ (irrespective of their distribution or magnitude) should also follow a lognormal distribution. Thus, it follows from this hypothesis that a logistic risk function provides a simplified model that represents the cumulative impact of any number of

lognormally distributed underlying risk factor contributing to the closure risk. Therefore, determining $Risk_{Closure}$ using a logistic function with input parameters of qualified funding and total closure activity costs (yellow section in Figure 1) provides a simple and effective method to estimate the probability and severity of those "worst case scenario" risks and to account for them in the activity's buffer contributions.

Liminal boundaries are applied to the risk score inputs to create a piecewise function, as shown by the green, yellow, and red sections in Figure 1. These liminal boundaries of the piecewise function are informed by the study conducted by EERC and its experience in developing Class VI permit applications. The first boundary at 5% (bounding the red section in Figure 1) is to ensure that activities are ineligible when they have insufficient qualified funding to cover the approximate costs of emergency injection well plugging and abandonment. This is the most significant leakage pathway for activities meeting the requirements of Tool 3: Activity Emissions and Monitoring Requirements for Geological Storage, if the storage site operator becomes insolvent. The related maximum score applied to $Risk_{Closure}$ is conservatively based on the maximum cumulative leakage rates observed by EERC using statistical modelling over a 100-year horizon.

The second boundary at 95% (bounding the green section in Figure 1) is as a conservative cutoff, beyond which marginal increases to qualified funding result in *de minimus* reductions to $Risk_{Closure}$. This boundary functions as an incentive for proponents to demonstrate qualified funding for closure activities.

Only activities for which $Risk_{Closure}$ falls within the defined green and yellow sections (Figure 1) are eligible.

DOCUMENT INFORMATION

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