Technical Appendix for GSAQI CPRG Funding Application

1 Analytical Approach and Reference Case

This appendix summarizes a range of mitigation measures that address emissions from sectors in Idaho, including Agriculture, Buildings, Natural and Working Lands, and Waste. Within each sector, Energy and Environmental Economics, Inc. (E3) worked with the Idaho Department of Environmental Quality (DEQ) to quantify multiple GHG emission reduction measures and specific programs or activities for Idaho's Priority plan.

E3 developed a tool to estimate the GHG and associated co-pollutants emissions impact of each proposed measure in compliance with EPA guidance (attached GHG emission reduction calculations spreadsheet (GHG Calcs)). Emissions reductions estimates draw on E3's deep industry and subject matter expertise but reference publicly available literature, data, and tools where possible. GHG emissions impacts, costs, and cost-effectiveness results are summarized at the individual measure and portfolio levels, both in this Appendix and the attached GHG Calcs.

In general, GHG benefits of each measure are calculated by multiplying a number of funded 'units' by an incremental GHG improvement factor relative to a reference case in which no action is taken. For example, the manure management GHG benefits are calculated as the annual emissions per head multiplied by the avoided emissions from the manure management strategy per head. The specific inputs and assumptions used to derive this calculation necessarily vary considerably by sector and measure; detailed calculations, as well as extensive documentation of inputs, assumptions, and sources, are provided in the attached GHG Calcs. While inputs and assumptions are naturally uncertain, we have worked to minimize through primary research and agency experience. Analyses included in the attached GHG Calcs are designed to be updated as newer or better information becomes available and as program implementation guidelines are solidified.

2 Measure Implementation, and Activity Data, GHG and Cost Assumptions

DEQ worked closely with other stakeholders in the state to identify and define measure scope, including a realistic implementation timeline for the measure, the lifetime of the measure, and the funding required for implementation. Detailed measure implementation schedules, costs, and lifetime assumptions are documented in the supplementary workbook.

Table 1 2025-2050 Electricity Grid Emissions Factors for Idaho (MT/MWh)

	100-yr GWP	Grid-Wide	Distributed PV	Portfolio EE	Uniform EE
CO_2e	1	0.11269	*0.68263*	*0.67545*	*0.67148*

Measures share a common set of emission assumptions including grid emissions factors (Table 1) and fuel emissions factors (Table 2). Global warming potentials (GWPs) for non-CO_2 GHGs are taken from the IPCC 5th Assessment Report (AR5). All GHG emissions reductions are reported in this appendix as CO2e; the attached GHG Calcs breaks out emissions by pollutant and certain co-pollutants for each measure.

Table 2 Fuel Emissions Factors[1]

Fuel	Combustion Type	CO2	CH4	N2O	Unit
Natural Gas	Stationary	56.06	0.001	0.0001	Kg/MMBTU
Coal	Stationary	103.69	0.011	0.0016	Kg/MMBTU
Propane	Stationary	61.46	0.003	0.0006	Kg/MMBTU
Wood	Stationary	93.80	0.0072	0.0036	Kg/MMBTU
Gasoline	Mobile	0.01	0	0	lbs/Gallon

2.1 Agriculture- Sustainable Agriculture Measure

GHG Reduction Estimate Method and Assumptions, Models, and Tools:

Idaho has 2 programs in the Sustainable Agriculture measure. The Animal Operations and Farm Efficiency Program used the E3 GHG tool to estimate emissions from *Manure Management, Enteric Fermentation, and Irrigation Pump Efficiency Improvements.* The Healthy Soils program estimates GHG reductions from the *Soil Management,* DEQ is proposing to fund an incentive program for this mitigation type and used the E3 tool to estimate emissions.

E3 estimated the GHG benefits of *Manure Management* measures using Idaho-specific data from EPA AgStar,[2] a calculator tool developed by CARB, [3] and public data from 2018 Alternative Manure Management Program.[4] The GHG benefits of *Enteric Fermentation* measures were estimated following EPA-developed methodology.[5] Finally, E3 calculated the GHG benefits of *Efficient Irrigation Pumps* by estimating incremental energy reductions achieved by efficient equipment following methodologies developed by CARB,[6] multiplied by EE sector avoided emissions factors from AVERT. **Error! Bookmark not defined.** E3 used data from the CARB Emissions Factor Workbook to estimate GHG benefits of *Soil Management* measures. The documentation of all inputs, assumptions, and sources are provided in the attached GHG Calcs.

Key assumptions for the measure can be found in Table 4 below. E3 used data from the EPA Global Non-CO2 Greenhouse Gas Emission Projections & Marginal Abatement Cost Analysis Methodology for *Anaerobic Digestion*.[7] Costs for *Manure Management*, *Enteric Fermentation* were drawn from the same sources as the GHG benefits referenced above for each. E3 conducted a literature review to estimate representative costs of adoption of efficient irrigation pumps.[8]

DEQ is proposing a grant program for the Animal Operations and Farm Efficiency Program. This grant program will provide 60% of the total project cost and recipients will provide a 40% match of personal capital. Because the 40% match would not occur without the 60% provided by DEQ, 100% of the emission reductions were calculated. When calculating GHG emission reductions, the activity data reflects the activity that can be done with 100% of the project cost (60% DEQ CPRG funding request + 40% grant recipient match). The overall funding also assumed a 30% federal tax credit for anaerobic digesters. See the attached GHG Calcs for details on these costs.

DEQ did not use costs from the E3 tool for *Soil Management* as they were provided in a specific budget from the University of Idaho (UI). UI relied on their past project experience and expertise related to the proposed incentive program, see Budget and narrative for more information on these costs.

Measure Implementation Assumptions and Measure-Specific Activity Data:

The manure management mitigation type considered 6 AgStar practices including Considered Anaerobic Digesters, Compost Bedded Pack Barn, Composting, Solid Storage, Manure Drying Practices, Semi-Permeable Covers. Each of these practices were estimated to be equally implemented each year through 2026 and 2027 (e.g. 8.33% of 115,000 head was assigned to compost bedding in 2026). Enteric fermentation adoption (25,000 head) and irrigation pump replacement (555 pumps) efficiency were assumed to be implemented equally from 2026-2027.

The Soil Management mitigation type considered four climate smart agricultural practices fertilizer management (15,000 acres), No till or till reduction (5,000 acres), grazing management (5,000 acres), and adding cover crops (10,000 acres) implemented at 20% of the total acreage implemented from 2025-2029.

2.2 Buildings- K-12 Energy Efficiency Program

GHG Reduction Estimate Method and Assumptions, Models, and Tools:

DEQ provided E3 with proposed building sector measures including *Electricity Energy Efficiency, HVAC-Fuel Energy Efficiency, HVAC-Building Electrification, and Weatherization for the K-12 Building Efficiency Program.* DEQ used the E3 tool assumptions to calculate reductions in the attached GHG Calcs.

The National Renewable Energy Laboratory (NREL) maintains publicly available databases of residential[9] and commercial[10] building types and characteristics, including existing heating equipment, heating fuel, and energy use. E3 drew on Idaho-specific data from these databases as a reference baseline from which to calculate the energy savings of multiple proposed buildings measures (*HVAC-Fuel Energy Efficiency, HVAC-Building Electrification, and Weatherization*). Potential electricity savings and costs associated with *Electricity Energy Efficiency* are based on data from the AEG PacifiCorp IRP support Conservation Potential Assessment,[11]. For the equipment E3 used 15 years as the life of the equipment for electrification.

E3 generally calculated avoided GHG emissions for this measure based on EPA sources. The exception is *Electricity Energy Efficiency*, where avoided emissions were calculated using portfolio energy efficiency sector emissions from AVERT**Error! Bookmark not defined.**. Specific sources are detailed in full in the attached GHG Calcs, and subset of key references are listed for reference in Table 4. The Idaho Power Technical Reference Manual was used for K-12 schools.[12] Costs were calculated as the cost premium between improved equipment and the cost of like-for-like replacement of existing equipment.

Measure Implementation Assumptions and Measure-Specific Activity Data:

DEQ refined details measure activities, including the types and numbers of schools to be addressed and the equipment or upgrades considered shown in Table 4. For building electrification DEQ assumed that 12 coal 61 propane furnaces or boilers would be upgraded. DEQ worked with ISDE that received input from school districts, Idaho design lab, and OEMR to assess need and capacity for this activity data. DEQ is planning a two-year grant opportunity where 50% of the activity will be implemented in 2025 and 50% in 2026.

2.3 Natural and Working Lands Sector- Sustainable Land Management

GHG Reduction Estimate Method and Assumptions, Models, and Tools:

DEQ provided E3 with the number of acres and existing land types where improved forestry and land management could be implemented in Idaho for the *Sustainable Land Management* measure. Complete calculations and documentation of sources and assumptions are provided in the attached GHG Calcs.

E3 first developed a per-acre abatement rate. This was calculated by estimating the maximum GHG reductions potential for each proposed land management practice nationwide based on peer-reviewed literature, limiting these values to GHG mitigation achievable at a cost below \$50/ton CO_2e.[13] E3 determined an average per-acre GHG abatement potential for each practice by dividing maximum annual abatement by the total US land area where that measure could be applied. Land areas for this calculation were taken from 2023 EPA inventory estimates.[14] E3 then multiplied per-acre abatement rates derived through the proposed acreage and land types provided by DEQ to calculate total GHG benefits.

The per-acre implementation cost estimates were developed in consultation with Idaho Fish and Game (IDFG) and Idaho Department of Lands (IDL) to determine specific costs based on years of experience completing like projects. See the attached Budget Narrative for more details on costs.

Measure Implementation Assumptions and Measure-Specific Activity Data: The Sustainable Land Management measure assumes each of the acres is treated with natural forest management, fire management and improved plantations treatments implemented equally from 2025-2029. IDL will be responsible for 9,837 acres and IDFG 1,792 acres that would make up the state target of 11,629 total acres. DEQ assumed 20% of the target acreage would be implemented annually from 2025-2029.

2.4 Natural and Working Lands Sector- Conservation and Restoration Program

GHG Reduction Estimate Method and Assumptions, Models, and Tools:

DEQ used the E3 tool to quantify emissions for Conservation and Restoration. DEQ provided the number of acres and land types restoration and conservation practices could be deployed in the state of Idaho. Complete calculations and documentation of sources and assumptions are provided in the attached GHG Calcs.

Same as the measure above, E3 first developed a per-acre abatement rate. This was calculated by estimating the maximum GHG mitigation potential for each proposed land management practice nationwide based on peer-reviewed literature, limiting these values to GHG mitigation achievable at a cost below \$50/ton CO_2e.[15] E3 determined an average per-acre GHG abatement potential for each practice by dividing maximum annual abatement by the total US land area where that measure could be applied. Land areas for this calculation were taken from 2023 EPA inventory estimates.[16] E3 then multiplied per-acre abatement rates derived through the proposed acreage and land types provided by Idaho DEQ to calculate total GHG benefits.

The per-acre implementation cost estimates were developed in consultation IDFG, IDL and Idaho Coalition of Land Trusts (ICOLT) to determine specific costs based on years of experience completing like projects. See the attached Budget Narrative for more details on costs.

Measure Implementation Assumptions and Measure-Specific Activity Data:

DEQ worked closely with IDL, IDFG, and ICOLT to determine the number of acres possible and specific land types for the funding of this measure shown in the table below. These partners identified 366 riparian, 500 forest, and 500 rangeland acres to restore for a state total of 1,366 acres to be restored equally 2025-2029.

The total state conservation goal for conservation is 18,634 acres implemented equally across rangeland, forest, riparian, wetland, and agricultural lands from 2026-2029. Many of these acres are going to be conserved as a result of due diligence funding. Due diligence are activities which ground truth the legal and physical aspects of an easement and are required for every easement. Cost varies for these activities depending on the project, e.g. 5% of the total project cost where the easement itself is funded by other state funds, or 100% of the total project cost where the landowner donates the land. The CPRG NOFO states that DEQ can only account for emissions directly from CPRG funding, so DEQ took into account emission reductions from only 10% of the acreage that was reserved for these funds (15, 634 acres for due diligence, only 1,563 acres were calculated for emission reductions). See attached GHG Calcs for details on calculations.

Table 3 Acreage Summary for Conservation acres

Partner	Conservation actual (acres)	% of acres counted	Acres for GHG emissions
IDL	**12,634**	**10%**	**1263.4**
IDFG	**3000**	**100%**	**3000**
ICOLT	**3000**	**10%**	**300**
Total	**18,634**	**1**	**4,563**

2.5 Waste Sector- Waste Diversion

The waste diversion measure includes recycling and composting components. DEQ and E3 estimated the size of the waste management programs that could be implemented in Idaho, quantified as tons of waste diverted from landfill to either recycling or mixed organic composting programs.

E3 calculated net GHG emissions reduction factors for both recycling and composting programs relative to landfill using EPA WARM emissions factors.[17] These factors were multiplied through the annual tonnage recycled or composted to calculate GHG benefits. E3 only counted emissions from the original tonnage of diverted waste so DEQ does not take credit for the emission reductions from the waste that is diverted from the program in future years.

Capital and operational cost estimates for recycling programs were calculated from a literature review in combination with publicly reported cost of existing recycling programs in Idaho Falls.[18,19] E3 developed a representative range of cost estimates for composting programs based on a literature review of compost operations in the United States and Europe.[20]

Measure Implementation Assumptions and Measure-Specific Activity Data: DEQ estimated 14,000 short tons of waste diverted per year totaling 70,000 tons of total waste diverted 2025-2029. DEQ estimated that 10% of the total waste diverted (50% recycling, 50% organic) in 2025 since it is the first year of the program, thereafter 22.5% of the total waste would be diverted annually 2026-2029.

Table 4 Summary of proposed measure assumptions, cost and GHG impacts, key sources, and high-level methodology

Note: GHG abatement calculations are shown in simplified form. Please refer to attached GHG Calcs for detailed emissions calculations and assumptions.

Measure Sector	Measure Type/ strategy	Total Units Deployed 2025-2029	Implement -ation Timing	Unit CapEx ($/unit)	GHG avoided per unit (MTCO2e/unit /Yr)	Key Data Sources, Models/Tools	Simplified GHG Benefits Calculation
Sustainable Agriculture	**Manure Management**	115,00 head	50% 2026 50% 2027	Avg $370 / head	2.2 / head	EPA[21,Error! Bookmark not defined.], CARB[Error! Bookmark not defined., 22], see budget and narrative	*n_head_covered * GHG_avoided/head*
	Enteric Fermentation	25,000 head	50% 2026 50% 2027	$126 / head	0.7 / head		*n_head_covered * GHG_avoided/head*
	Irrigation Pump Efficiency	555 pumps	50% 2026 50% 2027	$2,100 / pump	6 CO2e/Pump		*n_pumps_installed * GHG_avoided/pump*
	Soil Management	35,000 acres	20% 2026-2029	partner specific budget	0.3 / acre		*n_acre_covered * GHG_avoided/acre*
K-12 Building Efficiency	**Electricity Energy Efficiency**	82 buildings	50% 2026 50% 2027	$15,121-101,535 / building	13.4-106.9 / building	NREL[23,24], AEG PacifiCorp[25]	*electricity savings * n_ buildings * grid_emissions_factor*
	HVAC – Fuel Energy Efficiency	82 buildings	50% 2026 50% 2027	$3,500-6,000/ building	14.1-79.1 / building	NREL[9,10]	*(existing fuel savings * electricity emission factor + natural gas use increase* natural gas emission factor) * n_buildings*
	HVAC – Building Electrification	73 buildings 12 coal, 61 propane	50% 2026 50% 2027	$129,360 / building	31.1 / building	NREL[9,10], Idaho Power[12]	*(existing fuel savings * fuel emission factor + electricity increase* electricity emission factor) * n_buildings*
	Weatherization	72 buildings	50% 2026 50% 2027	$52,990-90,840 / building	13.3-32.8 / building		*(existing fuel savings * fuel emission factor + electricity savings * electricity emission factor) * n_buildings*
Sustainable Land Management	**Sustainable Land Management**	11,629 acres	20% 2025-2029	partner specific budget (see narrative)	0.358 / acre	EPA[14], Fargione et al. 2018[13],	*n_acres * ghg_mitigation_per_acre*
Conservation and Restoration	**Conservation and of Idaho's Lands**	18,634 acres	20% 2025-2029	partner specific budget	0.0096-0.3249 / acre		*n_acres * ghg_mitigation_per_acre*
	Restoration of Idaho's Lands	1,366 acres	20% 2025-2029	partner specific budget	0.0152-0.361 / acre		*n_acres * ghg_mitigation_per_acre*
Waste Diversion	**Recycling**	35,000 short tons/year	10% 2025 22.5% 2026-2029	$51 / short ton	2.84 / short ton	EPA WARM v16[17]	*tons_waste_diverted * (landfill_emissions_factor - recycling_emissions_factor)*
	Composting	35,000 short tons/year	10% 2025	$300 / short ton	0.29/ short ton		*tons_waste_diverted * (landfill_emissions_factor - composing_emissions_factor)*

			22.5% 2026-2029				

3 GHG emissions reduced for all measures.

Table 5: Measure-level GHG emissions reductions (metric tons CO_2e)

Measure Activity Name	Measure Scope	Average Annual GHG Reductions 2025-2030	Cumulative GHG Reductions 2025-2030	Average Annual GHG Reductions 2025-2050	Cumulative GHG Reductions 2025-2050
		($MT\ CO_2e$)/ yr	($MT\ CO_2e$)	($MT\ CO_2e$)/ yr	($MT\ CO_2e$)
Sustainable Agriculture	Includes manure management, enteric fermentation, irrigation electrification, soil management	191,701	1,150,207	242,202	6,297,264
K-12 Energy Efficiency	Includes electricity Energy Efficiency, HVAC Fuel energy Efficiency, HVAC Building Electrification, and Weatherization	8,465	50,792	8,605	223,739
Sustainable Lands Management	Includes natural forest management, fire management and Improved plantations treatments	2,743	16,457	3,798	98,742
Conservation and Restoration	Includes land types conserved by conservation easement and land types undergoing restoration	575	3,449	796	20,692
Waste Diversion	Includes Composting and recycling	18,258	109,550	4,213	109,550
Total		**221,742**	**1,330,454**	**259,615**	**6,749,988**

4 Selected References

A subset of key references discussed in the text are included in this Appendix. Please refer to the attached GHG Calcs *Data Dictionary* tab for a comprehensive list of inputs and sources used in measure and program calculations.

[1] EPA GHG Emissions Factors Hub
[2] https://www.epa.gov/agstar/practices-reduce-methane-emissions-livestock-manure-management
[3] https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/cdfa_ammp_finalqm_6-21-23.pdf
[4] https://www.cdfa.ca.gov/oefi/ammp/docs/2018_AMMP_ProjectsAwarded.pdf
[5] https://www.epa.gov/sites/default/files/2019-09/documents/nonco2_methodology_report.pdf
[6] https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/carb_farmer_qm_draft_091923.pdf
[7] https://www.epa.gov/sites/default/files/2019-09/documents/nonco2_methodology_report.pdf
[8] AMT Pumps 430A-95, 6" 1750 Rpm Straight Centrifugal Pump
[9] https://comstock.nrel.gov/
[10] https://www.nrel.gov/buildings/resstock.html
[11] https://www.pacificorp.com/energy/integrated-resource-plan/support.html
[12] https://docs.idahopower.com/pdfs/EnergyEfficiency/Reports/2020TRM.pdf
[13] Fargione et al. 2018. Natural climate solutions for the United States. Available at: https://doi.org/10.1126/sciadv.aat1869
[14] https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf
[15] Fargione et al. 2018. Natural climate solutions for the United States. Available at: https://doi.org/10.1126/sciadv.aat1869
[16] https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf
[17] https://www.epa.gov/warm/versions-waste-reduction-model#v16
[18] https://recyclingpartnership.org/wp-content/uploads/dlm_uploads/2021/05/Paying-It-Forward-5.18.21-final.pdf
[19] https://www.idahofallsidaho.gov/CivicAlerts.aspx?AID=2541
[20] E3 developed an average estimate using the following sources:
https://zerowastecities.eu/wp-content/uploads/2023/11/ZWC_Understanding-the-costs_231121.pdf
https://dec.vermont.gov/sites/dec/files/wmp/SolidWaste/Documents/Final_APPENDIXC_Composting_ADTech_10_2013.pdf
https://dpw.dc.gov/sites/default/files/dc/sites/dpw/page_content/attachments/DC%20Compost%20Feasibility%20Study_vf_0417.pdf

https://a860-gpp.nyc.gov/downloads/4f16c390n?locale=en (Link to download file)
[21] *https://www.epa.gov/agstar/practices-reduce-methane-emissions-livestock-manure-management*
[22] *https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials*
[23] *https://comstock.nrel.gov/*
[24] *https://www.nrel.gov/buildings/resstock.html*
[25] ***https://www.pacificorp.com/energy/integrated-resource-plan/support.html***

Measure-Specific Documentation:	
Appendix Section	**NOFO requirement**
Section 1 and 2	**GHG Reduction Estimate Method**: Describe the methods used to arrive at the measure-related activity data or other outputs and the GHG emission reduction estimate (e.g., engineering estimates, modeling, existing publicly available tool or calculator).
Section 2, Table 4, Attached GHG Calcs	**Models/Tools Used**: List or describe the specific models or tools used to develop the GHG emission reduction estimate; the name of the developer/provider of the model/tool (e.g., EPA); and, any other detailed references (e.g., specific versions of the model or tool), as appropriate.
Section 2, Attached GHG Calcs	**Measure Implementation Assumptions:** Provide key assumptions related to the implementation of the GHG reduction measure (e.g., data supporting assumed rate of measure implementation, implementation milestones, measure lifetime, capital cost assumptions, operation and maintenance cost assumptions).
Section 2	**GHG Reduction Estimate Assumptions:** Provide key assumptions used as part of the method for estimating GHG emission reductions (e.g., emission rates; emission factors; input assumptions if modeling is used, such as cost and performance data, energy prices).
Section 1	**Reference Case Scenario (GHG Emissions or Activity Level)**: Describe the reference scenario that is used to quantify GHG emission reductions for each measure, as applicable. The type of reference scenario may differ depending upon the type of GHG reduction measure. For example, an activity-level reference scenario approach might include a reference level of energy efficiency for a type of energy use equipment or GHG emission intensity under standard market practice for a type of activity, application, or equipment.
Section 2, attached GHG Calcs	**Measure-Specific Activity Data:** Provide relevant activity data that is used for estimating GHG emission reductions for each measure. This may include data such as energy savings (e.g., MMBtu by fuel or MWh saved), electrical output (e.g., MWh), vehicle miles traveled, units of equipment installed, or other metrics used to track the implementation and/or effects of a GHG reduction measure. Applicants should use reasonable assumptions for measure implementation (e.g., market availability and level of use for a technology-related measure or level of participation for an activity-related measure).
Section 3 Attached GHG Calcs	**GHG Emissions Reduced:** For each GHG reduction measure, provide measure-specific estimated annual GHG emission reductions (e.g., absolute reduction in metric tons of CO2 equivalent [mtCO2e]) and cumulative GHG emission reductions for the periods 2025 through 2030, and 2025 through 2050.