County of Sonoma

Climate & Resilience Comprehensive Action Plan

Basis of Direct Costs & Benefits Estimates

August 2024

Overview

County staff estimated costs and benefits for each County measure and action. This memorandum summarizes the methods and results of those calculations. The land-based costs and benefits are high-level estimates. Nature-based solutions and climate smart practice costs and benefits are site specific. They cannot be determined through desk-top analysis. However, ballpark cost and benefit estimates are necessary for planning purposes. These numbers should only be considered relative to each other for County planning purposes but are in no way representative of actual cost, value, nor carbon sequestration.

Estimates of benefits are based upon carbon sequestration coefficients associated climate-smart practices as defined by the Carbon Stock Inventory and Potential Sequestration Study. Benefits are estimated for the average lifetime of the practices considered in the measure, if the practice lifetime was for one year, savings are multiplied by 6 to represent benefits through 2030. In some cases, benefits were derived from published studies.

Note that comparisons of carbon sequestration and GHG emissions reductions from fossil fuel use are not equivalent as the timescales those forms of carbon are stored in the landscape differ. Climate smart practices lead to carbon sequestration in plants and soils. The time carbon is sequestered in this form depends on the lifetime of the matter (For ex. The lifetime of a tree determines how long it stores carbon, when it dies and decomposes it becomes a source of carbon). Whereas fossil fuels, prior to use, are sequestered deep in the earth and can remain stored there for longer periods of time. This is why carbon sequestration benefits are estimated for the lifetime of the practice, which estimates how long additional carbon is stored for because of the practice.

Estimates of costs were estimated based on planning costs, staff time and implementation costs. Plan costs were estimated based on past studies and plans conducted by the County. Since each measure and action is not described down to the project detail, the number of staff hours needed is not set and instead estimated based on similar recent efforts. Implementation costs were derived from state and federal datasets for programs that incentivize climate smart practices on working and natural lands. Some measures only include planning efforts in the near, mid or long-term efforts. In some cases, planning efforts will impact the County's ability to provide the services presented. In those cases, cost of the measure includes planning costs, however the benefits represent added GHG emissions benefits of implementation. Cost effectiveness (Cost/MTCO2e) is derived from the total cost, including implementation, divided by total benefits. This memo includes:

- Tables of measures, estimated costs, benefits, and references.
- General approach to direct cost and benefit calculations for each sector.
- Descriptions of how costs and benefits were characterized and calculated, and assumptions made.

Energy Measures

Table of Energy Measures

Energy County Operations Measures & Actions						
Measure #	Estimated Cost	Est. Cost Reference	GHG Benefits (MT CO2e)	Benefits Reference	Lifetime Savings	Net Cost/MT
E-CO-1	$28,226,572	SST Board Item 2024-0302	4,607	SST Board Item 2024-0302	$42,094,840	-$2,264
E-CO-2	$81,097,962	SST Board Item 2024-0302	109,864	SST Board Item 2024-0302	$61,600,000	$177
E-CO-3	> $100,000,000	SST Board Item 2024-0302	Not Quantifiable			
E-CO-4	$63,767 per year	SCP Energy Usage Data	48.6 MT CO2e per year	SCP Energy Usage Data & Evergreen Program		$1,312
E-CO-5	$90,000	Estimate of staff time; LEED Codes & Standards; CAPCOA GHG Quantification Handbook	Not Quantifiable			
E-CO-6	$350,000	LEED Building Costs	Not Quantifiable			
E-CO-7	$20,000	Estimate of staff time	GWP of refrigerants from 1.0 to 14,800	CARB Refrigerant Mgmt Reg. FAQ	Not Quantifiable	
E-CO-8	$300/light install $2k/light savings/yr	Based on similar fleet study	18.4 lbs CO2e/light per year or 0.0083 MT CO2e/light per yr	Corte Madera Streetlight Project	No Data	
E-CO-9	$10,000	Estimate of staff time	Not Quantifiable			
E-CO-10.4	$7M	Estimate of staff time	~ 45.2 MT CO2e/yr per system	Assumes 1 MW system; See E-CO-1	$19,943,730	-$9,546

Approach to Quantifying Energy Measure Direct Costs and Benefits

County staff worked with the PG&E Sustainable Solutions Turnkey (SST) Program to identify potential cost-effective energy upgrades throughout County infrastructure. A summary of the preliminary findings was presented to the Board on December 11, 2023. The final investment grade audit report and an Energy Conservation Assessment presented on March 15, 2024[1]. See the Board Meeting Agenda and attachments to review the SST Audit including the methods for calculating direct costs and benefits of energy measures and actions.

Not including facilities/systems contained in the preliminary new County Center project scope, staff selected buildings were reviewed within the Investment Grade Audits, which identified upgrades within 9 scopes of work equivalent to a $37 million investment that can produce 18.3 million lbs. of municipal GHG reductions.

Staff has organized the Investment Grade Audit upgrades completed for 66 county owned facilities. The Sonoma Public Infrastructure team will be responsible for overseeing the project contract. Staff costs are projected to be approximately 10% of the total project cost.

Additional Mid-term Energy Upgrades totaling about $81 million and longer-term improvements of over $95 million were identified. However, although they can result in significant GHG emissions reductions, these do not pay for themselves in utility cost savings, future cost increase avoidance or are associated with aged and uncertain life cycles.

Costs and benefits in the energy section were calculated for the lifetime of infrastructure upgrades or installations unless otherwise noted.

Methods for Specific Energy Measures

E-CO-1: See SST Program Presentation for quantification of costs and benefits[2]. Upgrades within 5 scopes of work equivalent to $28.9 million investment that will reduce 14.6 million lbs. over the life of the project. Achieving these reductions requires $2.4 million/year in debt payment over 20 years, yields an estimated annual average energy operational savings of $2.6 million/year over the life of the loan. The baseline cost savings, future cost increase avoidance, and $4.5 million available incentive supports a 13-year investment payback.

[1] https://sonoma-county.legistar.com/LegislationDetail.aspx?ID=6664595&GUID=43C2B4AD-CBEB-45E1-9EE7-5B69E414FD03&Options=&Search=
[2] https://sonoma-county.legistar.com/LegislationDetail.aspx?ID=6664595&GUID=43C2B4AD-CBEB-45E1-9EE7-5B69E414FD03&Options=&Search=

E-CO-2: See Staff Report for the Financing Energy Upgrades Board Report[3]. The construction cost of all the Mid-term Energy Upgrades is $81,344,673. These are identified facility improvements that do not pay for themselves in utility cost savings, future cost increase avoidance but will result in significantly more GHG emissions savings than the previously recommended upgrades and can be phased in by 2030. These additional measures, primarily concerning electrifying and upgrading existing, end-of-life equipment and installing Electric Vehicle charging infrastructure, are projected to result in substantial GHG emission reductions.

E-CO-3: See Staff Report for the Financing Energy Upgrades Board Report[4]. Excludes cost of new County Center.

E-CO-4: Costs and benefits were based on current energy usage and energy source emissions. Assumption, currently 85% of County use Sonoma Clean Power (SCP) Evergreen energy supplies. Cost of SCP existing accounts through 2030.

E-CO-5: Cost was based on LEED characterization of cost, Codes & Standards model policies and CAPCOA GHG Quantification Handbook[5].

E-CO-6: Estimated staff costs. Cost of modelling and LEED based on past estimates.

E-CO-7: Cost for LEED Commission analysis.

E-CO-8: Cost of LED Light conversions based on the Town of Corte Madera's Streetlight retrofit Project[6]. Payback period is 5.28 years; or 3.59 years if maintenance savings are $53.64/light per year. $300/light install $2,000/light savings/year. Assuming 287.8 kWh/ light per year at 0.064lbs/kWh, based on the PG&E generation profile. Project life was assumed to be 15 years. There is no immediate cost for this item as there are only LED bulbs available for sale.

E-CO-9: Estimate of staff costs.

E-CO-10: See CARB Estimates on refrigerant emissions[7]. Benefits from implementing renewable energy installations in parks and creating solar charging hubs serving underserved communities. Estimates include costs of Level-3 electric vehicle charging stations as seen in literature (Balal & Giesselmann, Oxford, 2024)[8]. Assuming maximum of 45.2 MT/CO2e/year per system (scaled from E-CO-1).

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[3] https://sonoma-county.legistar.com/LegislationDetail.aspx?ID=6664595&GUID=43C2B4AD-CBEB-45E1-9EE7-5B69E414FD03&Options=&Search=
[4] https://sonoma-county.legistar.com/LegislationDetail.aspx?ID=6664595&GUID=43C2B4AD-CBEB-45E1-9EE7-5B69E414FD03&Options=&Search=
[5] https://www.airquality.org/ClimateChange/Documents/Handbook%20Public%20Draft_2021-Aug.pdf
[6] https://www.townofcortemadera.org/997/LED-Streetlight-Retrofit-Project-FAQs
[7] https://ww2.arb.ca.gov/sites/default/files/2020-08/rmp_program_faq.pdf
[8] Afshin Balal, Michael Giesselmann, Design of a Level-3 electric vehicle charging station using a 1-MW solar system via the distributed maximum power point tracking technique, *Clean Energy*, Volume 8, Issue 1, February 2024, Pages 23–35, https://doi.org/10.1093/ce/zkad084

Transportation Measures

Table of Transportation Measures

Transportation County Operations Measures & Actions						
Measure #	Estimated Cost	Est. Cost Reference	GHG Benefits (MTCO2e)	Basis for Benefits	Lifetime Savings	Net Cost/MT
T-CO-1	$14,100,000	2024 Fleet Electrification Assessment	3,333MT CO2e / yr for the entire fleet	2024 Fleet Electrification Assessment	$14,000,000	$4
T-CO-2	$130,000	See T-CO-1				
T-CO-3	$2,700,000	CARB Compliance Report	93 to 98% reduction in CO2e for 320 vehicles	CARB ACF; County Health Rankings & Roadmaps	No Data	$327
T-CO-4	$59,862,545	SCTA Innovative Clean Transit ZEB Roll-Out Plan 2023, Meyers et. al. 2021	5,394/ yr for the entire fleet	SCTA Innovative Clean Transit ZEB Roll-Out Plan 2023	$13,272,000	$728
T-CO-5	$7,526,324	Secured Grant Proposals	See T-CO-1			
T-CO-6	$550,000	Compliance Report for CARB Regulation	223 MTCO2e/year	CARB Tier 5 HD Standards; County Health Rankings & Roadmaps	Not Quantifiable	
T-CO-7	$18,000	Based on Costs of Past Projects	1,184	2024 Fleet Electrification Assessment, EPA-420-F-16-025	$1,152,000	-$96
T-CO-8	$10,000	Based on Costs of Past Projects	Not Quantifiable			
T-CO-9	$977,020	Costs of Past Plans	50% reduction in GHG baseline (2021) for employee commute is 2,600 MT CO2e/year	Municipal GHG Inventory	Not Quantifiable	
T-CO-10	TBD, Airport Sustainability Master Plan					
T-CO-11	$2.4 M - $7.5 per mile	Based on Costs of Past Projects	1,352 MT CO2e per year	GHG Quantification Handbook CalEEMod	Not Quantifiable	

T-CO-12	$360,000	Based on Costs of Past Projects	674	CARB Small-Off Road Engine Guidance	$ 270,000	$133

Approach to Quantifying Transportation Measure Direct Costs and Benefits

Costs associated with fleet transitions are constantly evolving as the industry excels toward more electric vehicle options at lower prices. The County's 2023 Fleet Electrification Assessment, Sonoma County's Transportation Authority's Clean Transit ZEB Roll-Out Plan, published studies and state regulations were referenced for transition costs and benefits. Benefits are accrued annually once the fleet has fully transitioned to meet the measure's goals. Because transition of County fleet will happen over the near-, mid-, or long- term timeframe the benefits are presented as MTCO2e per year. When applicable, regulatory timelines were utilized to estimate total measure benefits (as a multiplier for MT CO2e benefits per year).

Methods for Specific Transportation Measures

Below we discuss assumptions in calculations and references as well as the project life for each measure (this is the time it will take the County to transition vehicles or conduct planning and implementation activities).

T-CO-1: See Fleet Electrification Assessment, 2024 for cost and benefits methods. When all complete (project lifetime estimated to be 7 years), operational cost savings of $2M/yr. See Tables 1-5 for assumptions.

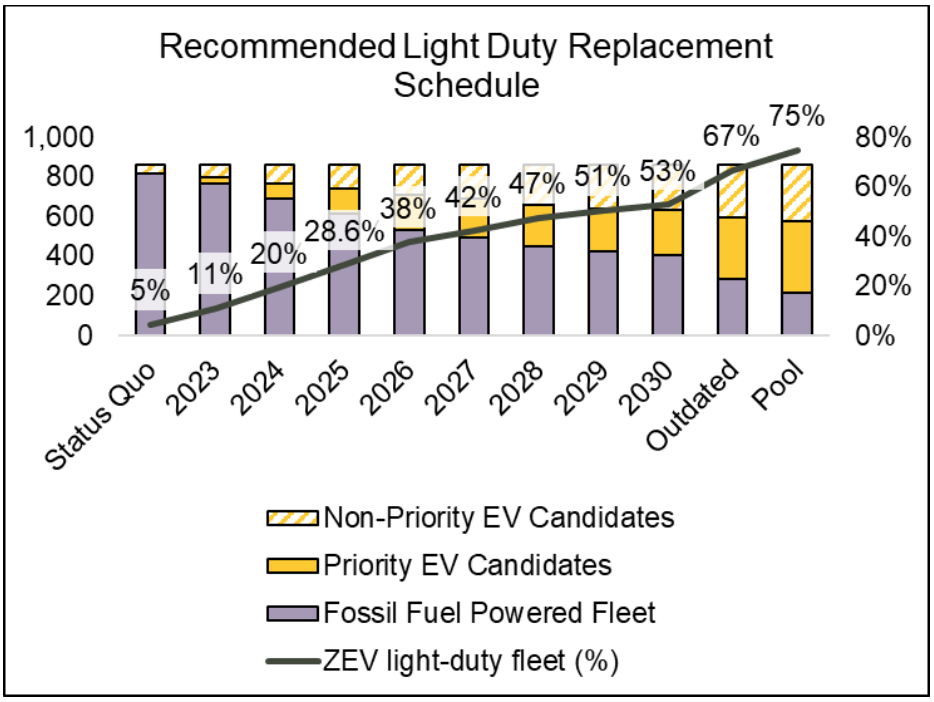

Figure 1. Recommended Light Duty Replacement Schedule

Fuel Type	Cost	Source
GAS	$4.65[9]	2023 EIA
PREMIUM GAS	$4.97	2023 EIA
DIESEL	$5.17	2023 EIA
ELECTRICITY	$0.34[10]	SCP evergreen

Figure 2. Fuel prices per gallon (for gas or diesel) or per kWh (for electricity)

Fuel Type	Co2e (Kg/gallon)	Source
Gas	8.50[11]	EIA
Diesel	10.19[12]	EIA

[9] EIA average monthly retail price in the California as of January 2023 - Energy Information Administration, Petroleum & other Liquids, Monthly retail gasoline and diesel prices - https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_r20_m.htm

[10] Avg. Bundled Electricity rate for Sonoma Clean Power customers enrolled in the Evergreen program with the B-10 TOU, secondary transmission utility tariff (https://www.pge.com/pge_global/common/pdfs/customer-service/other-services/alternative-energy-providers/community-choice-aggregation/scp_rateclasscomparison.pdf

[11] US Energy Information Administration, Carbon Dioxide Emissions Coefficients, https://www.eia.gov/environment/emissions/co2_vol_mass.php

[12] US Energy Information Administration, Carbon Dioxide Emissions Coefficients, https://www.eia.gov/environment/emissions/co2_vol_mass.php

Electricity (kilograms of CO2 per kWh)	0.00[13]	

Figure 3. Emissions Data (CO2)

Inflation rate (post-2021)	4.00%[14]
Inflation rate (pre-2021)	1.57%[15]

Figure 4. Annual inflation (used to determine replacement costs)

Years of ownership	Depreciation rate	Total vehicle depreciation
1	19%	19%
2	15%	34%
3	15%	49%
4	10%	59%
5	10%	69%
6	8%	77%
7	7%	84%
8	5%	89%
9	6%	95%
10	5%	100%

Figure 5. Vehicle Depreciation and Residual Value

	Internal Combustion Engine	plug-in hybrid electric vehicle	Hybrid Electric Vehicle
Internal Combustion	0%	-43%	-43%
Hybrid	30%	0%	0%
PHEV	40%	14%	14%
Electric	50%	29%	29%

Figure 6. Maintenance savings for electric and hybrid cars

T-CO-2: To initiate the pilot project of introducing a decarbonized pursuit vehicle into County fleet and operations, the County purchased two electric trucks (Ford Lightning) for approximately $85,000 per vehicle. Both need an additional investment of $40,000 to outfit the vehicle for enforcement use. An additional $50,000 is requested for a feasibility study and fleet decarbonization plan, this cost was determined based on the cost of past fleet

[13] Sonoma Clean Power EverGreen program produces electricity from 100% renewable sources (solar and geothermal)
[14] Assuming a higher average since the average inflation post pandemic - Source: https://tradingeconomics.com/united-states/inflation-cpi
[15] Average inflation for 2012-2020 - Source: https://www.usinflationcalculator.com/inflation/current-inflation-rates/

plans. This measure is required by California Air Resources Board (CARB) Advanced Clean Fleet (ACF) regulation. Along with compliance with regulations additional co-benefits include reduced GHG emissions over the lifetime of each vehicle. T-CO-1 benefits includes the GHG Emissions reductions resulting from transitioning pursuit vehicles.

T-CO-3: There are 19 vehicles theoretically marked for replacement per the CARB regulations (FY 2024--26). However, the majority cannot be replaced with an EV option due to the lack of available vehicles with necessary specifications, e.g., lack of high towing power. There are no electric vehicle options for Class 2b pickup trucks currently. Out of the 19, there are 4 vehicles which could be replaced at this time. To replace all 19 vehicles, departments would need to either downsize their vehicles, adjust their operations, or reduce the size of their trailers. Assuming the average cost of each of them would be $100,000, replacing 19 vehicles amounts to $1.9 million. For class 3 vehicles and above, the price is approx. $150,000. Most larger vehicles are still in a reservation system with no actual deliveries, and some are still in the proof-of-concept stage. Assumed lifetime of the project is 10 years.

T-CO-4: Assumed savings $237,000 per bus for 56 buses. This measure is required by CARB Innovative Clean Transit (ICT) regulation. Costs and benefits were calculated based on SCTA Innovative Clean Transit ZEB Roll-Out Plan 2023. See plan for more information. Costs were also informed by Meyers et. al. 2021[16]. Assumed lifetime of this project is 12 years.

T-CO-5: Benefits from this measure are included in the quantification of T-CO-1. County staff estimated costs based on a collaborative grant proposal drafted for the U.S. Department of Energy Efficiency and Conservation Block Grant recently submitted and awarded. Assumed lifetime of this project is 20 years.

T-CO-6: Emissions reductions values for benefits was informed by requirements set forth by CARB Tier 5 Heavy-Duty Vehicle rulemaking[17] and the impact these requirements reduce emissions by 93-98% which comes from the University of Wisconsin's County Health Rankings & Roadmap on Vehicle Emissions[18]. Cost estimates were informed by purchasing costs before the natural age of retirement and the type of equipment (e.g., mowers, tractors, etc.) in inventory. Cost of feasibility study is based upon past fleet plans. 223.76 MT CO2e/yr; assumes all Regional Parks offroad base inventory with an avg 95.5% reduction in emissions.

T-CO-7: Estimate of staff time to develop policy, annual fuel savings and cost of parking enforcement, assuming a project life of 10 years to transition 320 vehicles to zero-emission vehicles (ZEV). 3.7 - 9 MT CO2e/year are reduced per truck (saves 360 - 900 gal of fuel/year). 320 vehicles that qualify for the ACF regulation (Per the 2024 Fleet Electrification Assessment). Data on emissions from SmartWay Transport Partnership a Glance at Clean

[16] Meyers, Jonathan C., "The Great Transition: A Cost-Benefit Analysis of Transitioning from Diesel Fuel Buses to Zero Emission Electric Buses for the NFTA in The Buffalo-Niagara Falls MSA" (2021). Applied Economics Theses. 44. https://digitalcommons.buffalostate.edu/economics_theses/44

[17] https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2021/hdim2021/isor.pdf

[18] https://www.countyhealthrankings.org/strategies-and-solutions/what-works-for-health/strategies?page=2

Freight Strategies: Idle Reduction (EPA-420-F-16-025, June 2016)[19]. Costs of parking enforcement would increase if a public reporting service was provided. This estimate is assuming remote enforcement through telematics.

T-CO-8: Estimate of staff time.

T-CO-9: Costs estimated based on cost of staff involvement. Benefits calculations assume 50% reduction in 2021 GHG emissions for staff commute. Cost of feasibility study is based upon past fleet plans. These costs are not reflective of implementation therefor, the cost effectiveness for direct costs is not available until the feasibility studies are complete.

T-CO-10: Data not currently available. The Sonoma County Airport's Sustainability Master Plan is currently under development. When available the cost of those planning efforts and the estimated cost and benefits from enhancing procedures and other opportunities to reduce on-the-ground emissions from aircraft, and advocating for cleaner aviation fuels and fuel economy standards will be available. **Referred to as T-CO-11 in Cost Benefit Assessment.*

T-CO-11: Costs are based on recent Sonoma County Regional Parks Class 1 Bikeway projects. Benefits were derived from the Handbook for Analyzing GHG Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity[20]. Assumed lifetime of this project is 4 years. **Referred to as T-CO-13 in Cost Benefit Assessment.*

T-CO-12: Calculations are based on Parks' typical annual replacements. Assumes all Regional Parks' small offroad engines are replaced with zero-emission vehicles in four years. There is an estimated $1500/year saved per commercial leaf blower capital cost.

[19] https://19january2017snapshot.epa.gov/sites/production/files/2016-06/documents/420f16025.pdf
[20] https://caleemod.com/documents/handbook/full_handbook.pdf

Waste Measures

Table of Waste Measures

Zero Waste County Operations Measures & Actions					
Measure #	Estimated Cost	Est. Cost Ref	Quantitative Benefits (MT CO2e)	Basis for Benefits	Net Cost /MTCO2e
ZW-CO-1	$288,491	ZWACS	Reference ZW-CO-2/4/6		
ZW-CO-2	$685,000	ZWACS	851	US EPA WARM model	$805
ZW-CO-3	$107,914	ZWACS	1,276	US EPA WARM model	$84
ZW-CO-4	$209,413	ZWACS	638	US EPA WARM model	$329
ZW-CO-5	$68,641	ZWACS	Not Quantifiable		
ZW-CO-6	$177,439	ZWACS	13	US EPA WARM model	$13,664
ZW-CO-7	$138,885	ZWACS	265	US EPA WARM model	$524
ZW-CO-8	$50,000	Estimate of staff time	Not Quantifiable		
ZW-CO-9	$50,438	ZWACS	2394	US EPA WARM model	$21
ZW-CO-10	$807,734	ZWACS	TBD		

Approach to Quantifying Waste Measure Direct Costs & Benefits

The County of Sonoma Municipal Zero Waste Audit and Characterization Study (ZWACS) was drafted in collaboration with SCS Engineers. SCS Engineer's core capabilities are solid and hazardous waste management, landfill gas, site remediation, renewable energy, and regulatory compliance for air, water, and soil. This expertise allowed them to develop reasonable cost estimates for each measure. Benefits were estimated using the US EPA WARM Model. County waste production totals were aggregated to represent an annual percentage of materials within the waste stream as identified in the summary of key metrics supporting the County of Sonoma Municipal Zero Waste Audit and Characterization Study (ZWACS). The EPA Waste Reduction Model (WARM)21 was used to determine the GHG emissions from the current levels of waste per the baseline totals. Assumptions were made regarding diversion volumes to illustrate the impact of moving toward Zero Waste through a whole systems approach.

- Near -Term, and Mid-Term Waste diversion goals were identified through Sonoma County and Sonoma Zero Waste reports. Baseline GHG missions were calculated using extrapolated data from the reference reports.
- The WARM model was used to calculate the GHG emissions for alternative diversion from baseline aligning with the county's Near and Mid Term goals.

The WARM Model

Input the total potentially divertible, divertible, and compostable material into the WARM Model, based on the ZWACS. 52.9 tons per week of material, or 66.8% of the landfill waste stream, is made up of divertible, compostable, or potentially divertible materials. Multiply that number by weeks in a year, and by the percentage. This amount will equate to the total GHG mitigated and reduced by 2030, on an annual basis, by percentage (not compounded), for potentially divertible, divertible, and compostable waste at all County facilities.

Per this, the modeling was based on waste diversion percentages outlined in ZWACS and the CR-CAP timeline for measures and actions implementation.

[21] https://www.epa.gov/warm

Measure Code	ZW-CO-1	ZW-CO-2 ZW-CO-3	ZW-CO-4	ZW-CO-5	ZW-CO-6	ZW-CO-7 ZW-CO-8	ZW-CO-10
Year	2024	2025	2026	2027	2028	2029	2030

Figure 7. Measure Timeline. This timeline is further developed by management method in Figure 2 which shows the shift in waste tonnage from landfill to alternative management methods and Figure 3 which shows the cumulative impact on GHG emissions per year.

Methods for Specific Waste Measures

Baseline: For comparison of the effectiveness of the changes in materials management practices, the baseline waste generation used was 4,389 tons per year sent to landfill resulting in 835.3 MTCO2e baseline GHG emissions. For these calculations, the baseline waste generation was used through 2030 as current census data indicates that Sonoma County is not experiencing significant population growth and potentially has a declining population by recent estimates.

ZW-CO-1: Establishes a measurable Zero Waste program with leadership and accountability in all County departments and at all county facilities to increase waste diversion. This measure is not associated with any directly measured waste diversion or GHG emissions reduction.

ZW-CO-2: Establishes facility-specific near-term measures and actions to increase waste diversion by 50% of the readily divertible materials identified in the 2023 Zero Waste Audit and Characterization Study for each facility type. Per SCS estimates, this measure results in 821 tons of waste diversion and results in GHG emissions of -851 MTCO2e (980 MTCO2e total reduction from baseline). This GHG emissions impact is equal to taking 203 cars off the road, equivalent to carbon sequestration by 14,071 tree seedlings grown for 10 years.

ZW-CO-3 : Achieves compliance with statewide organic waste diversion requirements outlined in SB 1383 which states by 2025 reducing organic waste to landfill by 75% and diverting 20% of donatable food. Per SCS estimates, this measure results in 1,138 tons of waste diversion and reduces GHG emissions of -1,276 MTCO2e (1,469 MTCO2e total

reduction from baseline). This GHG emissions impact is equal to taking 304 cars off the road, equivalent to carbon sequestration by 21,099 tree seedlings grown for 10 years.

ZW-CO-4: Increases diversion of organic waste to 100%. Per SCS estimates, this measure results in 486 tons of waste diversion and reduces GHG emissions of -636 MTCO2e (732 MTCO2e total reduction from baseline). This GHG emissions impact is equal to taking 151 cars off the road, equivalent to carbon sequestration by 10,516 tree seedlings grown for 10 years.

ZW-CO-5: Reviews the diversion outcomes of near-term measures and actions and develops a comprehensive Zero Waste Plan. This measure is not associated with any directly measured waste diversion or GHG emissions reduction.

ZW-CO-6: Decreases the use of disposable food ware for onsite and offsite County-facilitated dining by 100% through a County-wide policy. Per SCS estimates, this measure results in 7 tons of waste diversion and reduces GHG emissions of -13 MTCO2e (15 MTCO2e total reduction from baseline). This GHG emissions impact is equal to taking 3 cars off the road, equivalent to carbon sequestration by 10,516 tree seedlings grown for 10 years.

ZW-CO-7: Develops centralized universal waste collection stations in every County facility. Per SCS estimates, this measure results in 184 tons of waste diversion and reduces GHG emissions of -265 MTCO2e (305 MTCO2e total reduction from baseline). This GHG emissions impact is equal to taking 63.1 cars off the road, equivalent to carbon sequestration by 4,382 tree seedlings grown for 10 years.

ZW-CO-9: Enhances waste diversion outcomes for the Reuse/Recycling Program Center to achieve full diversion. Per SCS estimates, this measure results in 1,697 tons of waste diversion and reduces GHG emissions of -2,394 MTCO2e (2,756 MTCO2e total reduction from baseline). This GHG emissions impact is equal to taking 570 cars off the road, equivalent to carbon sequestration by 39,585 tree seedlings grown for 10 years.

ZW-CO-10 This measure is separated from the prior measures as this measure solely deals with GHG emissions from closed landfills in Sonoma County and is not associated with any waste diversion. The GHG Inventory Report[22] provides estimates of the landfill emissions from closed landfills in Sonoma County, the report states:

> "This emissions factor will continue to decrease into Mid-term through natural processes leading to wholistic emissions reduction. This will take place over the closed lifecycle of the landfill."

22 https://sonomacounty.ca.gov/Main%20County%20Site/Administrative%20Support%20%26%20Fiscal%20Services/CAO/Documents/Climate%20Action%20and%20Resiliency/SonomaCounty-GHGInvReport-Final_Remediated.pdf

Nature-Based Measures

Approach to Quantifying Nature-Based Measures Direct Costs & Benefits

The costs and benefits of nature-based solutions are challenging to quantify because the climate smart practices involved are site specific. Practice planning and implementation is largely determined holistically, considering co-benefits beyond carbon sequestration (e.g., water quality, air quality, health benefits, etc.) and the need for climate smart practices at a site (e.g., erosion, flood, drought etc.). These evaluations are often done with support from technical service providers with expertise in resource management. This analysis of direct costs and benefits was conducted based on theoretical data related to practice scale, cost, and GHG benefits. This analysis of cost and benefits is needed to estimate at a high-level, the potential scale of investment needed to implement climate smart practices and nature-based solutions at a landscape scale. Costs and benefits are estimated based on best available data and models and can be utilized for relative comparisons. This analysis does not represent actual project costs or carbon sequestration and should not be referenced at a project planning level.

To characterize the scale of nature-based costs and benefits, the County needed to acreage targets for implementation of climate smart practices. This analysis considered the local share of statewide targets for nature-based solutions, and the estimates of associated costs and benefits (please refer to the discussion in the CR-CAP Section VIII).This differs from the Cost Benefit Assessment which estimates the costs and benefits of doing a climate smart practice on all applicable land in Sonoma County as identified by the Carbon Stock Inventory and Potential Sequestration Study (CSIPSS)[23] (please refer to the Basis of Costs & Benefits Estimations in the Appendix).

California set targets for nature-based solution implementation[24]. Based on land-use types represented in Sonoma County a local “share” of these state targets was calculated for each category (forest, grasslands, shrublands, chaparral, barren, developed land, and working lands) (See CSIPSS for quantification of land use in Sonoma County). Acreage targets utilized in cost and benefit calculations were based on 2% of this share because this plan focus’ on the scale of County actions on County lands. This 2% is a heuristic that assumes the County owns 2% of each land type, which is not accurate. However, a detailed

[23] https://sonoma-county.legistar.com/LegislationDetail.aspx?ID=6399747&GUID=42EF9CFA-1B23-4B80-BE5C-6DC2B882A484
[24] https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/Californias-NBS-Climate-Targets-2024.pdf

assessment of land use based solely on County assets was not available and could enhance future calculations.

Direct costs and benefits do not include a quantitative assessment of co-benefits associated with each measure nor represent the benefits in the form of natural capital. See the CCIPSS for a qualitative break down of climate smart practice co-benefits. See Ag + Open Space's Healthy Lands & Healthy Economies Report[25] for an overview of the natural capital value of conservation of natural and working lands in Sonoma County.

Figure 1. Value of Natural Capital in Sonoma County - Healthy Lands & Healthy Economies Report

Annual Value of Natural Capital

Annual value provided by natural capital in Sonoma County, in millions of 2015 dollars. The range for each service indicates the low and high values estimates using the benefit transfer method.

Ecosystem Service	$ Millions Per Year Countywide (low estimate)	$ Millions Per Year Countywide (high estimate)
Water Supply	$9M	$180M
Wastewater Treatment	$35M	$117M
Moderation of Extreme Events	$82M	$220M
Urban Stormwater Management	$0.2M	$8M
Soil Retention and Formation	$4M	$620M
Carbon Sequestration	$58M	$197M
Air Quality	$19M	$22M
Pollination	$218M	$367M
Habitat and Nursery	$4M	$43M

[25] https://www.sonomaopenspace.org/wp-content/uploads/HLHE-Sonoma-Report-Ag-Open-Space-lores-1.pdf

Biological Control	**$8M**	**$23M**
Natural Beauty	**$1,214M**	**$4,182M**
Recreation and Tourism	**$500M**	**$596M**
GRAND TOTAL	**$2,151M (or $2.2 billion)***	**$6,575M (or $6.6 billion)***

** The totals reported are based upon rounded values from individual services. For precise values, please see the original study.*

Most nature-based measures implementation costs were evaluated in-part by quantifying the cost of climate smart practice implementation for practices that are well-documented and likely utilized to achieve measure goals. Implementation calculations required acreage targets, practice costs and planning costs, and carbon sequestration benefits. Not included in this assessment is the cost of permitting which can be significant for stewardship projects but are site specific. Planning costs were added to implementation costs, the data utilized to estimate planning costs differs for each measure and is detailed below.

Costs of climate smart practices were pulled from California Department of Food and Agriculture's (CDFA) 2023 Healthy Soils Program practice incentives list and the 2024 United states Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP)[26] practice incentive costs[27]. Both datasets represent only 50% of estimated practice costs. So, incentives were doubled and then inflated by 30-45% based on interviews with local land managers and agency representatives.

The CSIPSS provided Carbon Sequestration Coefficients from California Department of Conservation's Terra Count dataset[28]. GHG benefits for the average "life" of the practices considered. The practice life is an estimate of the duration of time for which it sequesters CO2e at a reliable rate. See the CSIPSS for a table of practices and their life.

In cases where there was not a direct crosswalk between the CSIPSS practice lists and coefficients, USDA NRCS Standardized Conservation Practices[29],County measures, and the State NBS Targets. This is described in the measure-specific methods in the Water, Wildfire and Natural and Working Lands sections below. When multiple practices represented a nature-based solution measure, the costs from all were averaged. In this way the estimates do not capture the most expensive or cost-effective practices but represent a suite of practices and their average costs.

[26] https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives
[27] https://www.nrcs.usda.gov/sites/default/files/2023-12/fy24-california-eqip.pdf
[28] https://maps.conservation.ca.gov/TerraCount/
[29] https://www.nrcs.usda.gov/getting-assistance/conservation-practices

To align with state goals, to get an idea of potential scale of implementation, measures consider practice implementation on only one land type. This is unrealistic, as likely a practice could be applied on many land types and beneficially overlap with implementation of other practices. In reality, there can be additional benefits gained and dollars saved by combining practices. This nuance was not captured in this analysis. For this effort, overlap was avoided to avoid double counting of costs and benefits.

Water Measures

Table of Water Measures

Water County Operations Measures & Actions							
Measure #	**Estimated Cost**	**Est. Cost Reference**	**Lifetime Benefits (MTCO2e)**	**Benefits Reference**	**Practice Life (Years)**	**Lifetime Savings**	**Net Cost/MT**
W-CO-1	$560,000	Past projects W-EA-5	64.7	Past projects W-EA-5	60	$540,000	$170
W-CO-2	$4,595,125	2024 USDA NRCS EQIP, CSIPSS	34,812	CSIPSS, State NBS Target Forest Restoration (riparian zones)	45		$132
W-CO-3	$57,594	2023 CDFA HSP	7,059	CSIPSS, State NBS Target Forest Afforestation	20		$8
W-CO-4	$39,519	2023 CDFA HSP	730	CSIPSS, State NBS Target Grassland Restoration	30		$54
W-CO-5	$1,327,000	See E-CO-1	~23.6 lbs CO2e per thousand gallons saved	See E-CO-1			
W-CO-6	$450,000	Past plans	Data Unavailable				
W-CO-7	$1,000,000	Past plans	Data Unavailable				
W-CO-8	$1,850,000	Past plans and City of SB Grant Proposal	Data Unavailable				

Methods for Specific Water Measures

W-CO-1: Costs and benefits were derived from W-EA-5 based on avoided truck trips, adjusted for this measure $11,111 / kgal (Capital); $444 / kgal (life net); $4,252/MT CO2e for capital costs; $170/MT CO2e net lifetime. Estimated 1.96 MTCO2e per year is. Benefit calculations assume truck decarbonization after 30 years.

W-CO-2: Planning costs estimated based on past studies. Cost data builds upon data from 2024 USDA EQIP Incentives. Data on 391 activities on grazing lands and cropland were available. All activities for grassland and cropland were averaged. Although cropland and grazing lands were not the target land type for the measure, these estimates were the best available data. Planning costs are included in cost estimates for W-CO-8 and W-CO-7. Acreage targets were based on State NBS Targets for Forest Restoration (including Riparian zones). Riparian restoration practices include:

- Riparian Herbaceous Cover (390)
- Riparian Forest Buffer (391)
    - Activities include bare-root hand planting, cuttings small to large, and small to large containers hand planted, and broadcast planting.

W-CO-3: Tree and Shrub Establishment (612) activities on cropland, grazing land, orchard and or vineyard. Cost data builds upon data from 2023 CDFA HSP Incentives. Although this measure focus' activities on upland watershed or variable land use types, this is the best available cost data. Activities include conservation through hand planting and browse protection. Planning costs are included in cost estimates for W-CO-8 and W-CO-7. Acreage targets were based on State NBS Targets for Forest Afforestation.

W-CO-4: Planning costs are included in cost estimates for W-CO-8 and W-CO-7. Benefits were calculated for 6 years although practice lifespan surpasses that. Acreage targets were based on State NBS Targets for Grassland Restoration. All practice cost data comes from 2023 CDFA HSP Incentives.

Costs estimates were based on the following practices:

- Silvopasture (381)
- Prescribed Grazing (528)
- Compost (808)

GHG Benefits estimates were based on the following practices:

- Oak Woodland Restoration
- Native Grassland Restoration
- Compost Application to Rangelands (CPS 808)
- Native Oak Restoration/Silvopasture (CPS 381)

W-CO-5: Data taken from the SST audit & ECA to extrapolate to additional facilities & new construction. See E-CO-5 for policy development costs. CO2e savings are from water conservation In SST E-CO-1.

W-CO-6 & 7: Costs based on past plans. Data not available on benefits.

W-CO-8: Costs based on past plans and grant proposals for similar work. Data not available on benefits. Implementation costs were taken from City of Santa Barbara's Sea-Level Rise Adaptation Plan (SB SLRAP) Benefit-Cost Analysis prepared by AECOM (Protect & Retreat Scenario; Section 12-23 pg.246)[30]. This estimate is the lower end of the SB SLRAP implementation costs (higher estimates of protect strategies were >$4 billion). However, this is a coastal city so impacts may be greater than in Sonoma County.

30 https://sustainability.santabarbaraca.gov/sites/default/files/documents/Services/SLR%20Adaptation%20Plan/ADOPTED%20Sea-Level%20Rise%20Adaptation%20Plan.pdf

Wildfire Measures

Table of Wildfire Measures

Wildfire Resilience County Operations Measures & Actions						
Measure #	Estimated Cost	Est. Cost Reference	Lifetime Benefits (MTCO2e)	Benefits Reference	Project Life (years)	Net Cost/MT
WF-CO-1	$400,000	Approved Board Item 2024-0026	Not Quantifiable			
WF-CO-2	$550,000	Past plans	Not Quantifiable			
WF-CO-3	$157,450	2024 USDA NRCS EQIP, 2023 CDFA HSP, Estimate of staff time	4,384	CSIPSS, State NBS Target Forest Fuel Reduction	27	$36
WF-CO-4	$697,000	2024 USDA NRCS EQIP, 2023 CDFA HSP, Estimate of staff time (excl. impl.; incl. impl. In net cost/MTCO2e)	19,727	CSIPSS, State NBS Target Forest Fuel Reduction	27	$71
WF-CO-5	$717,524	2024 USDA NRCS EQIP, 2023 CDFA HSP, Estimate of staff time	19,727	CSIPSS, State NBS Target Forest Fuel Reduction	27	$36
WF-CO-6	$50,000	Estimate of staff time (excl. impl.; incl. impl. In net cost/MTCO2e)	22,777	CSIPSS, County Public Infrastructure Website	6	$169
WF-CO-7	$200,000	Not Quantifiable				

Approach to Quantifying Wildfire Measure Direct Costs and Benefits

The approach to quantifying wildfire measures differed slightly from other NBS measures. State NBS targets encompass all fire-related activities into two measures: beneficial fire and fuel reduction of forests, shrublands, and grasslands. Measures W-CO-3,4, and 5 are based on an estimated percentage of the acreage recommended for forest, shrubland, and grassland fuel reduction activities in the County portion of state NBS targets.

It should be noted that the County has made significant strides towards developing and implementing long-term wildfire resiliency programs that surpass the simplified state goals. These programs include diverse activities that include, but are not limited to, the following:

- Adopting a Community Wildfire Protection Plan (CWPP) with a Wildfire Resiliency Index, a CWPP web portal, and a CWPP project prioritization process.
- Adopting a fully updated and revised Multi-Jurisdiction Hazard Mitigation Plan.
- Developing a whole community, landscape scale approach to protecting life, safety, and property as well as nature-based solutions and ecosystem health in the FEMA funded Wildfire Resiliency Sonoma County project.
- Implementing a series of early warning, early detection systems.
- Developing a Vegetation Management Grant Program for community wildfire preparedness projects.
- Implementing post-fire road repair and improvements to ensure rapid and orderly evacuation from remote locations.
- Implementing and planning wildfire and forest ecosystem projects across County Regional Park lands.
- Developing a natural and working lands resiliency strategy for the County.

Methods for Specific Wildfire Measures

WF-CO-1: This measure is on-going and planning costs are based on the budget approved by the Board of Supervisors[31].

WF-CO-2: Costs based on past plans.

WF-CO-3: Acreage targets were based on State NBS Targets for Fuel Reduction Practices (grazing, mechanical, timber harvest) on forest lands for Sonoma County targets. Benefits were calculated for 6 years although practice lifespan surpasses that. Benefits were calculated based on CSIPSS coefficients for Fuel Reduction, Improved Forest Management

[31] https://sonoma-county.legistar.com/LegislationDetail.aspx?ID=6519226&GUID=5FB7741D-8B6D-44F4-AA89-0FEAB310867B&Options=&Search=

Thinning from Below for forests for all of Sonoma County. Costs were based on 2024 USDA NRCS EQIP Incentives. It was assumed buffer areas would cover 10% of the County's portion of state NBS targets for Forest Fuel Reduction Activities.

Costs estimates were based on the following practices:

- Fuel Break (383)
- Woody Residue Treatment (384)
- Forest Stand Improvement (666)
- Tree-Shrub Pruning (660)
- Prescribed Grazing (528)
    - Activities in practices include slash, lop and scatter, chipping and spreading, chipping, and hauling, air curtain burner, stand improvement, mechanical light and heavy equipment use, rangeland grazing and hand tools.

GHG benefits were based on CSIPSS estimates for Fuel Reduction, Improved Forest Management Thinning from Below, and Prescribed Grazing (CPS 528) (Rangelands).

WF-CO-4: Acreage is estimated to be 45% County portion of State Fuel Reduction Target. Estimated staff time (focus on Regional Parks land). See W-CO-3 for practices and activities included. Costs for implementation of these activities are estimates to be approximately $708,524. These costs are not included in the measure cost as the measure is focused on planning. However, it is included in the net cost per MTCO2e of the measure because benefits represent a post-implementation scenario.

WF-CO-5: Acreage is estimated to be 45% County portion of State Fuel Reduction Target. Estimated staff time. See W-CO-3 for practices and activities included.

WF-CO-6: Estimate of staff time and technical support based on past project costs. Acreage estimates are based on the lane miles of road managed by the County (2,747.28 lane miles)[32]. Mileage was then converted into acres by assuming roadside treatment area was 4-8 feet wide (6ft on average). [33] So roadside treatment acre is assumed to be 87,033,830 sq. ft. or 1,998 acres. Costs estimates were based on the following practices:

- Fuel Break (383)
- Woody Residue Treatment (384)
- Forest Stand Improvement (666)
- Tree-Shrub Pruning (660)
    - Activities in practices include slash, lop and scatter, chipping and spreading, chipping, and hauling, air curtain burner, stand improvement, mechanical light and heavy equipment use, and hand tools.

[32] https://sonomacounty.ca.gov/development-services/sonoma-public-infrastructure-(formerly-tpw)/divisions/roads/services/mile-totals
[33] https://dot.ca.gov/-/media/dot-media/programs/maintenance/documents/17-chpt-c2-july-2014-rev-1-02-a11y.pdf

GHG benefits were based on CSIPSS estimates for Fuel Reduction and Improved Forest Management Thinning from Below.

Costs for implementation of these activities are estimated to be approximately $3,792,331. These costs are not included in the measure cost as the measure is focused on planning. However, it is included in the net cost per MTCO2e of the measure, because benefits represent a post-implementation scenario.

WF-CO-7: Estimate of staff time and technical support based on past plans.

Natural & Working Lands

Table of Natural and Working Lands Measures

Natural and Working Lands County Operations Measures & Actions						
Measure #	**Estimated Cost**	**Est. Cost Reference**	**Lifetime Benefits (MT CO2e)**	**Benefits Reference**	**Practice Life (years)**	**Net Cost/MT**
NWL-CO-1	See Ag + Open Space Programs		>40755	State NBS Conservation Targets (all land types); CSIPSS	6	$1,301
NWL-CO-2	$50,000	Online Salary Estimates	Not Quantifiable			
NWL-CO-3	$130,585	State NBS Target Forest Sparsely Vegetated Lands; 2023 CDFA HSP	88	State NBS Target Forest Sparsely Vegetated Lands; CSIPSS	6	$1,484
NWL-CO-4	$393,291	State NBS Target Forest Afforestation and Urban and Community Greening and Forestry; 2024 USDA EQIP	71,606	State NBS Target Forest Afforestation and Urban and Community Greening and Forestry; CSIPSS	20-50	$5
NWL-CO-5	$640,869	State NBS Target Forest Shrubland/Chaparral; 2023 CDFA HSP	526	State NBS Target Forest Shrubland/Chaparral; CSIPSS	30	$1,218
NWL-CO-6	$7,500	Not Quantifiable				
NWL-CO-7	$65,000	Not Quantifiable				

Methods for Specific Natural and Working Lands Measures

NWL-CO-1: NBS State Targets include conservation goals for each land use type and references the definition for conservation in The Pathways to 30x30 strategy. California's 30x30 goal defines a conserved area as "Land and coastal water areas that are durably protected and managed to sustain functional ecosystems, both intact and restored, and the diversity of life that they support". Sonoma Ag + Open Space permanently protects the diverse agricultural, natural resource, and scenic open space lands of Sonoma County for future generations. The evaluation of direct costs and benefits for this measure differs from others in that, there are several existing, funded, programs that works toward protection and conservation of Sonoma County lands. Estimated costs and benefits here are to showcase the significant contribution to meeting GHG emissions goals as a result of this work.

This measure only includes cooperative planning efforts and does not require near term funding. Direct costs and benefits of implementation of the County's portion of state conservation goals are estimated to cost over $53,000,000 and sequester over 40,000 MT CO2e. Costs and benefits acreage is based on State Conservation Goals for all land types summed. The cost of land acquisition is extremely nuanced, for this high-level estimate the current average of parcels on the market was calculated[34].Carbon sequestration benefits were estimated based on the CSIPSS practices Avoided Conversion to Row Crops and Avoided Conversion to Urban Land Uses.

NWL -CO-2: Estimate of consultation costs based on Tribal Consultant accrual on ZipRecruiter in the Bay area ($64,000-90,000/year).

NWL -CO-3: Estimate of staff time. Acreage estimates were based on State NBS Target for sparsely vegetated lands. Cost data is from both 2023 CDFA HSP and 2024 USDA NRCS EQIP. Benefit estimates are from the CSIPSS for Compost and mulch in orchard. Project life is assumed to be 5 years.

Costs estimates were based on the following practices (2023 CDFA HSP):

- Compost (808) on Orchard/Vineyard
- Mulching (484) on Cropland

GHG Benefits estimates were based on the following practices:

- Compost (808) on Cropland
- Mulching (484) on Cropland

[34] https://www.landwatch.com/california-land-for-sale/sonoma-county?src=google&medium=cpc&gad_source=1&gclid=CjwKCAjw4_K0BhBsEiwAfVVZ_yGwK4rvcDVeMzvUnPor8pBRL5Me825VYhLQduSvTpBrmV9rmhRP7hoCGWsQAvD_BwE&gclsrc=aw.ds

NWL-CO-4: Acreage estimates were based on State NBS Target for Afforestation and Urban and Community Greening and Forestry on developed (urban) lands. Costs estimates were based on the following practices:

- Tree/Shrub Establishment (612) (Cropland)

And GHG Benefits estimates were based on the following practices:

- Urban Forestry

NWL -CO-5: Estimate based on staff cost and past plans. Acreage estimates were based on State NBS Target for Shrublands/Chaparral restoration. Cost from 2023 CDFA HSP.

Costs estimates were based on the following practices:

- Silvopasture (381)
- Prescribed Grazing (528)
- Compost (808)

GHG Benefits estimates were based on the following practices:

- Oak Woodland Restoration
- Native Grassland Restoration
- Compost Application to Rangelands (CPS 808)
- Native Oak Restoration/Silvopasture (CPS 381)

NWL -CO-6: Estimate of staff costs.

NWL -CO-7: See WF-CO-1 for costs.