# Technical Appendix

The methodologies and assumptions of Tulsa Metropolitan Statistical Area's GHG Emission Reduction Measures.

## Resilience Hubs

Three existing City of Tulsa community/activity centers have been identified as desirable locations for the establishment of hardened neighborhood facilities to support residents in times of need before, during, and after hazardous weather events or disruptions in utility services. These facilities will be retrofitted with renewable energy equipment and batteries to allow for constant operational readiness when their services are needed most. Our scenario for emission reduction estimates assumes the stated upgrades are completed on three centers and we have based our reductions on the emissions calculated using the 2023 electricity in kWh purchased for each facility.

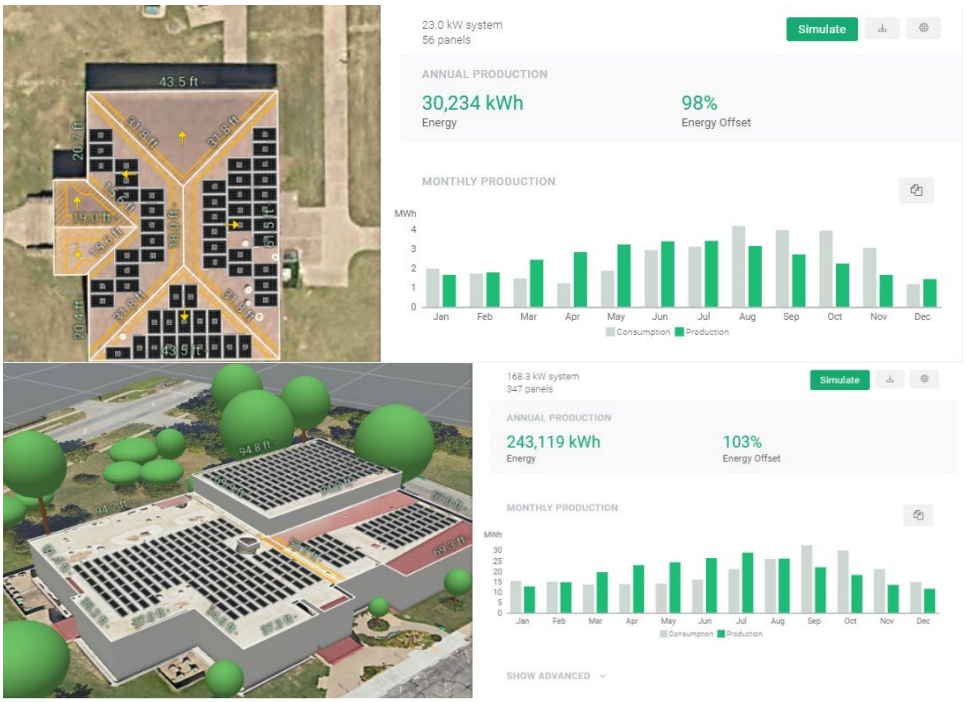
The EPA's Simplified GHG Emissions Calculator was used to calculate the annual emissions for each facility and multiplying the total by five (5) years for the total GHG reductions from 2025-2030 and twenty-five (25) years to determine the total GHG reductions from 2025-2050. According to the calculator, in 2023 the total CO2e emissions for all three centers was 655 Mt.

Assuming all three facilities are upgraded with solar arrays, batteries, and new energy efficient HVAC equipment and lighting, the total projected emission reductions from operations is approximately 3,275 Mt CO2e in 2030 and 33,020 through 2050.

3 x hubs = 655 Mt CO2 per year x 5 years = 3,275 MtCO2 2025-2030 GHG reductions

3 x hubs = 655 Mt CO2 per year x 25 years = 16,375 MtCO2 2025-2030 GHG reductions

Below is the electricity consumption data utilized for the solar assessments conducted by a local solar contractor.




## Electric Vehicle and Electric Equipment Incentives

GHG emissions in short tons, provided by AFLEET in annual values, were converted to GHG emissions in metric tons. The annual emissions reductions for each electric vehicle and piece of equipment were calculated by finding the difference between the annual emissions of the gasoline equipment and the annual emissions of the hybrid or electric vehicle/equipment. For estimated emissions reductions in the years 2025-2030, annual reduction estimates were multiplied by 5. For reduction estimates over 2025-2050, annual reduction values were multiplied by 25. Minimum and maximum cost effectiveness values for the 2025-2030 and 2025-2050 periods were calculated by dividing the maximum and minimum proposed incentive amounts for the vehicle/equipment by their respective emissions reduction volumes for the given period. Averages were then calculated for minimum and maximum cost effectiveness values across all vehicles/equipment. However, project total estimates were calculated based on the emissions reduction volumes and proposed incentive amounts using a proposed budget of $1,000,000 which reduces our initial PCAP projection reduction.

With $1,000,000 available for incentives through this program:

- An approximate total of 850 incentives will be awarded given an average incentive cost of $1,175.
- Approximately 9,145 metric tons of CO2-eq will be reduced from 2025-2030 given average reductions among all eligible vehicles/equipment of ~11 metric tons of CO2-eq over 5 years.

- Approximately 45,724 metric tons of CO2-eq will be reduced from 2025-2050 given average reductions among all eligible vehicles/equipment of ~54 metric tons of CO2-eq over 25 years.

| | | | | | | | Lifecycle Annual Air Pollutants (calculated from AFLEET) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vehicles | Minimum Cost Effectiveness Per Vehicle/Equipment, 2025-2030 (dollars per metric ton CO2-eq) | Maximum Cost Effectiveness Per Vehicle/Equipment, 2025-2030 (dollars per metric ton CO2-eq) | Proposed Maximum Incentive Cost Per Vehicle/Equipment | Proposed Minimum Incentive Cost Per Vehicle/Equipment | MPG | emissions reduced, 2025-2030 (metric tons CO2- | GHG emissions (metric tons CO2-eq) | GHG emissions (short tons) | CO (pounds) | NOx (pounds) | PM10 (pounds) | PM2.5 (pounds) | VOC (pounds) | SOx (pounds) |
| Passenger Car (gasoline) | | | | | 24.2 | | 5.5 | 6.1 | 34.6 | 0.7 | 0.8 | 0.2 | 3.7 | 0.1 |
| PHEV | 344 | 69 | 5000 | 1000 | | 14.51 | 2.6 | 2.9 | 26.2 | 0.5 | 0.8 | 0.2 | 2.5 | 0 |
| EV | 256 | 51 | 5000 | 1000 | | 19.50 | 1.6 | 1.8 | 0 | 0 | 0.7 | 0.1 | 0 | 0 |
| Light Truck/Van (gasoline) | | | 0 | | 17.5 | | 7.0 | 7.7 | 32.3 | 0.7 | 0.8 | 0.2 | 3.3 | 0.1 |
| PHEV | 283 | 57 | 5000 | 1000 | | 17.69 | 3.4 | 3.8 | 23.1 | 0.4 | 0.7 | 0.2 | 2.1 | 0 |
| EV | 216 | 43 | 5000 | 1000 | | 23.13 | 2.4 | 2.6 | 0 | 0 | 0.7 | 0.1 | 0 | 0 |
| E-Bike (electric pedal assist) | 73 | 15 | 2000 | 400 | | 27.25 | 0.08 | 0.09 | - | - | - | - | - | - |
| **Equipment** | | | | | | | | | | | | | | |
| Chain saw | | | | | | | 0.1 | 0.1 | 134.1 | 0.7 | 4.6 | 5.7 | 36.6 | 0 |
| electric | 441 | 88 | 200 | 40 | | 0.45 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lawn mower | | | | | | | 0.1 | 0.1 | 306.1 | 2.1 | 0.1 | 0.1 | 17.9 | 0 |
| electric | 1102 | 220 | 500 | 100 | | 0.45 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Leafblower | | | | | | | 0.2 | 0.2 | 614.1 | 4.2 | 0.2 | 0.3 | 23.4 | 0 |
| electric | 220 | 44 | 100 | 20 | | 0.45 | 0.1 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Trimmer/Edger/Brush Cutter | | | | | | | 0.0 | 0.03 | 65.7 | 0.7 | 2.1 | 2.6 | 18 | 0 |
| electric | 1220 | 244 | 100 | 20 | | 0.08 | 0.0 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 |
| Golf cart | | | | | | | 0.1 | 0.1 | 199.8 | 1.5 | 0.1 | 0.1 | 4.9 | 0 |
| electric | 441 | 88 | 200 | 40 | | 0.45 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Commercial Turf Equipment | | | | | | | 5.0 | 5.5 | 710.4 | 74.5 | 4.2 | 5.2 | 83.5 | 0.1 |
| electric | 11 | 2 | 200 | 40 | | 18 | 1.5 | 1.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lawn and Garden Tractor | | | | | | | 2.0 | 2.2 | 7361.2 | 49.6 | 2.6 | 3.3 | 163.6 | 0 |
| electric | 28 | 6 | 200 | 40 | | 7 | 0.5 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0 |

## Sources:

MPG - From AFDC.energy.gov "Average Fuel Economy by Major Vehicle Category" https://afdc.energy.gov/data/10310

GHG, CO, SOx, NOx, PM2.5, PM10, VOC
Calculated using AFLEET Tool - Argonne National Laboratory (anl.gov)

AFLEET defaults were used, except:

- For MPG, which was input with values from the AFDC that provide the average MPG of vehicles on U.S. highways.
- Annual usage hours were set at 52 for: Chain saw, Lawn mower, Leafblower, Trimmer/Edger/Brush Cutter, and Golf cart.

Annual lifecycle GHG emissions for an E-Bike were calculated using data from a peer-reviewed academic publication, Comparative life cycle assessment of electric bikes for commuting in the UK – ScienceDirect

## Energy Efficiency and Weatherization

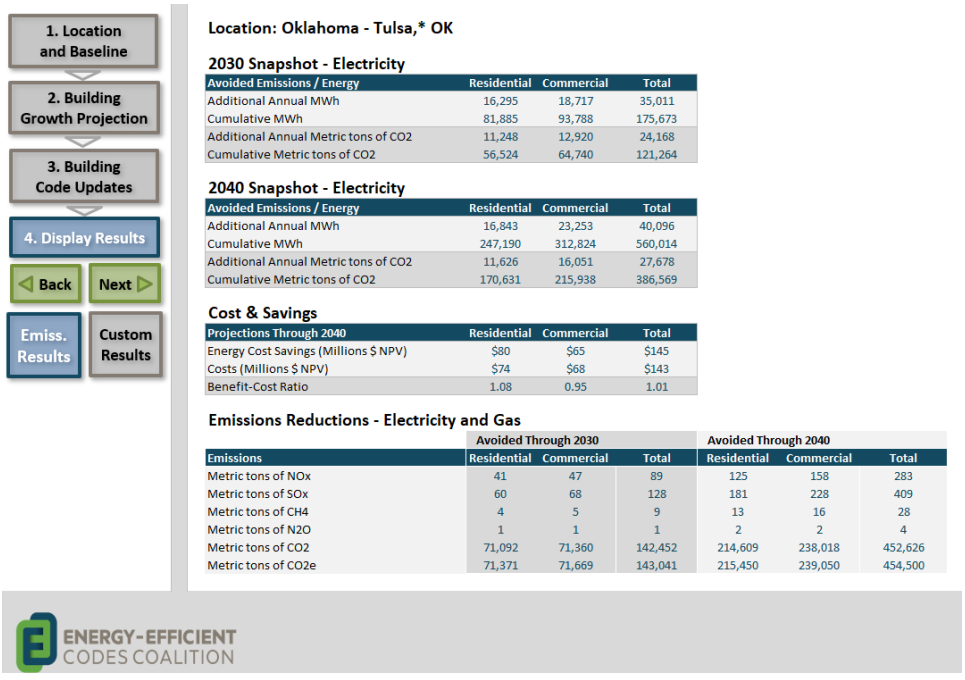
According to the Oak Ridge National Laboratory, "WEATHERIZATION ASSISTANCE PROGRAM TECHNICAL MEMORANDUM BACKGROUND DATA AND STATISTICS," published by Joel F. Eisenberg in March 2010, weatherization of a residential home reduces power plant emissions by 2.65 MtCO2e per year. INCOG's Energy Efficiency and Weatherization Program has a program goal and proposed budget to weatherize seventy-five (75) residential homes each year for four years.

75 homes x 2.65 MtCO2e per year x four years = 795 MtCO2e from 2025-2030

75 homes x four years = 300 homes x 2.65 MtCO2e per year x 24 years = 19,080 MtCO2e from 2025-2050

## Energy Efficient Building Codes

The Institute for Market Transformation, a Washington D.C. based nonprofit focused on increasing energy efficiency in buildings by bridging the gaps between government, business, and the community. According to their "Building Energy Code Savings Calculator", which the selected input of utilizing the 2018 International Energy Conservation Code (IECC) and a75% code compliance rate determined that the projected 2025-2030 GHG emission reductions for the Tulsa metro were approximately 199,034 Mt of CO2e and from 2025-2050 was 392,170 Mt CO2e.



## Energy Efficiency Revolving Loan

Energy Efficiency Revolving Loan Fund improvements have included new HVAC systems, a boiler, and installation of energy efficient lighting. Utility data is collected from the recipients to monitor each project's energy and cost savings. According to the data from the different facilities that received retrofits, on average the facilities observe about 187 Mt of CO2e annual reductions compared to the baseline utility data before the upgrades occurred. Based on funding and program goal to provide similar upgrades to three additional facilities per year the total potential GHG emission reductions are as follows;

2025-2030 - 4,488 Mt of CO2e

2025-2050 - 11,220 Mt CO2e

INCOG Revolving Loan Facility Energy Reports

Tulsa County Courthouse Revolving Loan Fund Energy Report

| | Current YTD | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total Project Savings |
|---|---|---|---|---|---|---|---|---|---|
| **Steam** | | | | | | | | | |
| Energy Savings (kWh saved | 106,846 | 70,142 | 4,007 | 12,799 | (11,261) | 37,487 | 78,194 | 106,846 | **405,059** |
| % Energy Savings | 54.39% | 36.69% | 14.35% | 9.87% | -7.70% | 18.12% | 40.58% | 54.39% | **28%** |
| Cost Saved | $ 63,054.45 | $ 82,458.64 | $ 4,257.67 | $ 12,762.18 | $ (9,477.64) | $33,737 | $ (17,099.00) | $ 63,054.45 | **$ 232,748.13** |
| % Cost Saved | 36% | 45% | 16% | 23% | -6% | 39.77% | 26% | 36% | **27%** |
| | | | | | | | | | |
| **Chilled Water** | | | | | | | | | |
| Energy Savings (therms sav | (28,335) | (921) | (17,201) | 15,165 | (35,856) | (13,115.50) | 2,635 | (28,335) | **(105,963)** |
| % Energy Savings | -41.97% | -4.09% | -32.51% | 18.32% | -32.62% | -26.06% | -16.27% | -41.97% | **-22%** |
| Cost Saved | $(79,674.02) | $ 45,837.97 | $ 29,685.27 | $ 57,876.27 | $ (72,582.16) | -$40,311 | $ (8,215.00) | $ (79,674.02) | **$ (147,056.99)** |
| % Cost Saved | -47% | 11% | 26% | 21% | -35% | -30.58% | -19% | -47% | **-15%** |
| | | | | | | | | | |
| **Electricity** | | | | | | | | | |
| Energy Savings (kWh saved | 424,200 | 214,319 | 217301 | 285200 | 24200 | 415,200 | 429,200 | 424,200 | **2,433,820.00** |
| % Energy Savings | 13.11% | 6.33% | 10.00% | 10.69% | 0.68% | 13.35% | 13.31% | 13.11% | **10%** |
| Cost Saved | $ 27,020.20 | $ 20,049.00 | $ 15,704.77 | $ 22,287.17 | $ 1,905.19 | $30,284 | $24,213 | $27,020 | **$ 168,483.93** |
| % Cost Saved | 12.60% | 9.09% | 7.43% | 12.85% | 3.70% | 0.15% | 8.87% | 12.60% | **8%** |
| | | | | | | | | | |
| **Total Savings** | $ 10,400.63 | $ 148,345.61 | $ 49,647.71 | $ 92,925.62 | $ (80,154.60) | $23,710 | $ (1,101.00) | $ 10,400.63 | **$ 254,175.07** |

Tulsa County O'Brien Park Facility

**Savings Post Construction - Electricity (amount, kWh)**

| | January | February | March | April | May | June | July | August | September | October | November | December | Annual Total Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | no data | no data | 7920 | 5200 | 2800 | **15920** |
| 2018 | -320 | -1280 | 3280 | 6720 | 640 | 3280 | 4080 | no data | no data | 2880 | 880 | 2240 | **22400** |
| 2019 | 1760 | 480 | 480 | 2400 | 9360 | 11680 | 9440 | no data | no data | 1040 | 5200 | 3440 | **45280** |
| 2020 | no data | no data | no data | no data | no data | no data | no data | no data | no data | 6400 | 1520 | 4400 | **12320** |
| 2021 | 1920 | 240 | 2480 | 2880 | 8400 | 2560 | 6320 | no data | no data | 4240 | 3040 | 2960 | **35040** |
| 2022 | 2160 | 2320 | 2960 | 3120 | 2240 | -2000 | 2480 | * | * | 6800 | 2320 | 2480 | **24880** |
| 2023 | 2400 | 1680 | 2560 | 960 | 3680 | 2720 | 2560 | * | * | 3168 | 1328 | * | **21056** |
| | | | | | | | | | | | | | |
| | | | | | | | | | **2023 % Savings** | | | | **16.33%** |
| | | | | | | | | | **Total Electricity Savings to Date, kWh** | | | | **176896** |

## Neighborwoods

Using the Land Use and Forestry Module Tool provided by the EPA, the net sequestration of Tulsa MSA, with its baseline year of 2017 as established for the PCAP, is 1,029,224 metric tons of CO2e sequestered. The Tulsa Urban Forest Master Plan (2016) commissioned by local non-profit, Up With Trees (Neighborwoods strategy), sets a goal of increasing the total tree canopy coverage in Tulsa County from 26% to 30% over 20 years.

Starting in 2025, if an additional 5,000 trees were planted throughout Tulsa MSA: According to deciduous tree maturity rates of 10 years, 36.4 lbs C/tree × (44 units CO2/12 units C) × 1 metric ton/2,204.6 lbs = 0.060 metric ton CO2 per urban tree planted. Then when those trees reach maturity in 2035, an additional 300 metric tons of C02 will be sequestered. Projecting out 15 years to 2050 gives a sequestration total of 7,500 metric tons of CO2.

Methodology

*36.4 lbs C/tree × (44 units CO2/12 units C) × 1 metric ton/2,204.6 lbs = 0.060 metric ton CO2 per urban tree planted x 5,000 trees over 4 years = 300 metric tons of CO2e.

If we stop the program at the end of the five-year mark, those trees will keep sequestering CO2. So, projecting out to 2050, in 25 years from 2025 those 5,000 trees will sequester an additional 7,500 metric tons CO2e:

Project Costs Assumptions

Project costs were derived from cost estimates provided by Up With Trees.

| | Number of trees | CO2e Sequestration rate per tree | Total | Cost Per tree | Cost-Benefit ($/CO2e) | |
|---|---|---|---|---|---|---|
| Year 1 | 1,250 | 0.06 | 75 | $650 | | |
| Year 2 | 1,250 | 0.06 | 75 | $650 | | |
| Year 3 | 1,250 | 0.06 | 75 | $650 | | |
| Year 4 | 1,250 | 0.06 | 75 | $650 | | |
| | 5,000 | | 300 | $650 | $2.17 | |
| | | | | | | |

*Sources:

EPA. Number of urban tree seedlings grown for 10 years (Calculations). 2024. Greenhouse Gases Equivalencies Calculator - Calculations and References | US EPA.

McPherson, E. G.; van D. N. S.; Peper, P. J. (2016). Urban tree database and allometric equations. Gen. Tech. Rep. PSW-GTR-253. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 86 p.

U.S. DOE (1998). Method for Calculating Carbon Sequestration by Trees in Urban and Suburban Settings. Voluntary Reporting of Greenhouse Gases, U.S. Department of Energy, Energy Information Administration (16 pp, 111K, About PDF).

## Riparian Area Conservation Easements and Wetland Restoration

The USDA's COMET-Farm Tool was used to estimate the annual and projected emissions reductions (metric ton CO2-eq) resulting from the implementation of NRCS Conservation Practices on a chosen acreage in a selected county. The two options selected:

- Replace a Strip of Grassland Near Watercourses or Water Bodies with Woody Plants (Mixed Hardwoods)
- Wetlands- Restore Highly Disturbed Areas by Planting Permanent Vegetative Cover

**Riparian Forest Buffer (CPS 391) Replace a Strip of Grassland Near Watercourses or Water Bodies with Woody Plants (Hardwood/Conifer, Mixed Hardwoods)**

COMET-Planner estimates for riparian forest buffer establishment assume replacing rangeland or managed pasture with unfertilized, woody plants (hardwood/conifer, mixed hardwoods). Impacts on greenhouse gases include woody biomass carbon accumulation and change in soil organic matter carbon due to cessation of tillage and increased carbon inputs from plant residues. Estimates apply only to the portion of the field where woody plants are established. GHG Estimation Methods Greenhouse gas emissions from soils were estimated using a sample-based, metamodeling approach with COMET-Farm, which employs the USDA entity-scale inventory methods (Eve et al. 2014). GHG reduction estimates represent the average impact of a conservation practice compared to baseline conditions, over a range of soils, climate and cropland management within multi-county regions defined by Major Land Resource Areas (USDA-NRCS 2006). Woody biomass accumulation rate models were derived for taxon groups (family or genus levels) from the USDA Forest Inventory and Analysis database and developed to be consistent with a forthcoming update to Eve et al. 2014. Details of the modeling approach will be described in a methods white paper that is currently under development. Estimates are not meant to apply to any specific site conditions but rather represent the range of expected values to be found over the multi-county region and reflect the assumptions stated.

**Critical Area Planting (CPS 342) Restoring Highly Disturbed Areas by Planting Permanent Vegetative Cover**

For moist/humid climates, the assumption is woody planting and biomass carbon sequestration and soil carbon changes were estimated using values from tree/shrub establishment. GHG Estimation Methods In moist/humid climates, woody biomass carbon estimates were derived from empirical models of woody biomass carbon accumulation in NRCS agroforestry prescriptions that used tree growth increment data from the U.S. Forest Service Forest Inventory and Analysis (FIA) program and allometric equations to allocate biomass carbon to tree components (Paustian et al. 2012, Merwin et al. 2009). Only herbaceous planting was assumed for dry/semiarid climate. Soil organic carbon estimates were based on North America sandy soils (Eve et al. 2014) as a proxy for disturbed soils.

Project Cost Assumptions

Project cost assumptions and estimated extent of project area were derived using data from reporting on comparable riparian area conservation easement projects in Eastern Oklahoma.

| Timeframe | Location | Contracts | Area (acres) | Easement Type | Annual Program Cost | Total Program Cost | Cost (per acre) | Cost (per acre/ per yr) |
|---|---|---|---|---|---|---|---|---|
| Current | Horse Creek Tributary Area | | 451 | 30-YR | | $981,704 | $2,177 | $72.56 |
| 2000-2004 | Illinois River Watershed Pilot Project | 65 | | Annual | | | | $50.00 |
| 2007+ | Illinois River- OK Scenic River Commission | 18 | 415 | | | $665,917 | $1,606 | $53.54 |
| Current | OCC and Conservation Districts in the Illinois River Watershed | 20 | 1093 | 15 YR | $66,602 | $999,023 | $914 | $60.93 |
| Current | Illinois River Watershed GRDA | | 1622 | 30-YR | | | | |
| Current | Grand Lake Watershed GRDA | | 451 | 30-YR | | | | |
| Current | GRDA Total | | 2073 | 30-YR | $131,409 | $3,942,255 | $1,902 | $63.39 |
| | **Average for Similar Projects in Northeast Oklahoma** | | | | | | | **$60.09** |
| **Proposed** | **Tulsa MSA** | | **775** | **30-YR** | | **$1,400,000** | **$1,806** | **$60.22** |

**Sources:**

Oklahoma Conservation Commission's Annual Non-Point Source Report to EPA

Long-term Riparian Area Protection in the Illinois River Watershed FY 2014 §319(h) EPA Grant #C9-996100-17 – Project 5, Task 4

Methodology and Project Approach

A study conducted by Olsson and Riverman Engineering for OCC in 2018 in the Tyner Creek Watershed Stream Stability Assessment compared costs and sediment reduction amounts using two different methods. This was used as the basis for the assumption that the more cost-effective option is also the less intensive restoration approach and will be used in the proposed project.

- **Tyner Creek Eroding Streambank Prioritization Study**
  - Compared geomorphic restoration vs. livestock exclusion and vegetative planting.
    - Cost- $1,000,000 protects 2.6 acres with geomorphic restoration vs. 666 acres livestock exclusion and vegetative planting.
    - Impact on sediment loading-1050 $yd^3$ sediment with geomorphic restoration vs. 144,020 $yd^3$ sediment with livestock exclusion and vegetative planting.