City of Manhattan Alternative Stormwater Compliance Program, Memo 1: Program Objectives and Recommended Policies

To: City of Manhattan, Public Works

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The purpose of this memo is to lay the groundwork for the creation of an alternative stormwater compliance program for the City of Manhattan as part of its MS4 permit. This program is expected to follow a fee-in-lieu of treatment model.

The overarching goal of this program is to enable the City to meet its MS4 permit obligations (i.e., to reduce pollutants to the maximum extent practicable) in a more environmentally- and economically-effective manner.

The foundational work to this envisioned offsite stormwater compliance program includes:

(1) a review of other alternative stormwater compliance programs and associated provisions in stormwater NPDES permits, including local examples of Wichita and El Dorado, Kansas;
(2) a review of the peer-reviewed literature regarding pollutant loads expected from urban land uses and potential load reductions achieved by water quality and soil conservation practices that could serve as suitable offsite BMPs;
(3) a review and assessment of water quality impairments and opportunities for offsite water quality practice implementation in surrounding watersheds; and
(4) a recommended framework for an alternative stormwater compliance program.

This memo is organized as follows: a brief background and rationale for the study, followed by a summary of the key takeaways from each of the foundational components listed above. A more detailed report on each of these components is provided as an Appendix (A.1 through A.4.7) to this memo.

Background. Alternative compliance typically encompasses options to implement water quality BMPs at an alternative location where environmental conditions are more amenable to BMP performance and/or can achieve water quality goals in a more cost effective manner.

KDHE provides an allowance for “alternative stormwater offsite pollution reduction programs” in the state’s general MS4 permit. This allowance states that “permittees may incorporate and implement plans through their SMO for an offsite pollution reduction program to install BMPs in alternative locations, including outside the Permit Area…for the joint purpose of reducing pollutant loads generated from urban and non-urban lands within the shared watershed." In short, the alternative stormwater compliance program defined by KDHE provides the opportunity to work across traditional governance boundaries (e.g., municipal or county) to more efficiently improve water quality and overall watershed health.

The City of Manhattan is currently exploring alternative stormwater compliance as part of their menu of options to address its National Pollutant Discharge Elimination System (NPDES) stormwater permitting requirements while also improving water quality in area watersheds, specifically by addressing total maximum daily loads (TMDLs) and/or other pollutants of concern.

Prior to developing this program, work is needed to establish the current state of the practice regarding alternative stormwater compliance programs. The state of the science regarding runoff pollutant loads from urban and agricultural land uses and effectiveness of appropriate BMPs is also needed to provide the quantitative underpinnings of an alternative stormwater compliance program. Finally, local considerations – including an assessment of surrounding watersheds as candidate offsite service areas, the types of offsite BMPs most likely to be implemented, and watershed partners with whom the City can work to secure a sustained flow of pollutant reduction credits – must be explored. This memo aims to address these information and preliminary assessment needs.

Summary of Key Takeaways

(1) *State of the Practice: Offsite Stormwater BMP programs*. A recent review by the U.S. EPA (2023) highlighted three models for implementing alternative stormwater complicance provisions via offsite stormwater best management practice (BMP) implementation as part of MS4 permit obligations. Of these, the fee-in-lieu model is most relevant to the program envisioned by the City of Manhattan. Programs with a fee-in-lieu mechanism in place for implementing an offsite stormwater compliance program – including Wichita and El Dorado, Kansas – follow a similar set of structural program elements but have defined these elements differently such that each program is customized to the uniques set of water resource concerns and types of offsite water quality practices that are most appropriate for the permit holder and surrounding area. Examples of how programs with fee-in-lieu programs in place have defined this common set of structural elements are provided for seven MS4 permit holders.

(2) *State of the Science: Pollutant loads and BMP load reductions in urban and rural contexts.* Stormwater pollutant concentrations and potential reductions by urban

stormwater BMPs were compiled from recent literatureRunoff pollutant loads were then determined from literature runoff concentrations and were used to define an *Effective Commercial Acre* (ECA), which serves as the basis of the "demand side" of the program; that is, the runoff pollutant load generated by urban development that must be offset by offsite BMPs for properties that opt to participate in the alternative compliance program. By comparison, edge-of-field runoff concentrations from cropland systems were generally higher than urban runoff. Concentrations from grazing land uses were similar to urban runoff. Runoff concentrations and associated pollutant loads from active urban construction were orders of magnitude higher than agricultural or post-construction urban land uses, particularly with respect to fine sediment; therefore, urban construction will continue to require on-site BMPs. Pollutant removal efficiencies for common urban and rural BMPs were also reviewed and demonstrated highly variable but generally positive pollutant retention, particularly for agricultural BMPs.

(3) *Local watershed: water quality threats and opportunties*. Candidate watershed areas surrounding the City of Manhattan were identified and described, with a particularly focus on documented water quality impairments. In terms of land use, pasture/grazing land is the dominant land use in all watershed areas, though all have substantial acreage of cropland. Sediment is a primary pollutant of concern watershed areas draining to Tuttle Creek while nutrients, particularly phosphorus, were identified as primary pollutants of concern through the TMDL process in the Blue and Kansas Rivers downstream of Tuttle as well as Wildcat Creek. Given its role in transporting nutrients and bacteria, sediment remains an important pollutant in these watersheds as well.

(4) *Recommendations for Fee-in-Lieu Program Framework*. Recommendations are presented for each of the following program elements: spatial bounds of the program service area, a method for accounting for pollutant load rates from new and redevelopments within the City of Manhattan and definition of an *Equivalent Commercial Acre* (ECA), pollutant credit ratio and other risk factors, "most likely" candidate BMPs to be implemented in the surrounding service area and method to account for pollutant reduction credits that they provide, key watershed partners, and recommendations for tracking program implementation and effectiveness (A.5.7). These recommendations were developed through discussions with City stormwater staff, KDHE staff, and staff from agencies and non-profits currently working with agricultural land managers in the identified service area.

Appendix A – Foundational Components of Alternative Compliance Program

Contents:

A.1. State of the Practice: Alternative Stormwater Compliance via offsite BMP programs

Alternative stormwater compliance options have been adopted by a growing number of Municipal Separate Storm Sewer Systems (MS4) throughout the US under the recognition that site constraints – be it physical, biological and/or economic – may limit the overall effectiveness of BMP performance and broader water quality efforts. Alternative compliance approaches typically involve options to implement water quality BMPs at an alternative location where environmental conditions are more amenable to BMP performance and/or can achieve water quality goals in a more cost effective manner. For example, constraints to stormwater management that may exist at the location where development is taking place can include soils with low infiltration rates, buried utilities, steep slopes, high groundwater tables, and/or lack of space, all of which can drive up the cost of BMP implementation and maintenance while, at the same time, limiting performance. To spur the development of alternative compliance approaches to stormwater management, the EPA recently released a compendium of alternative compliance options that can be incorporated in MS4 permits (USEPA, 2023). In this compendium, three mechanisms are identified through which alternative stormwater compliance programs can be implemented, including:

- Offsite *mitigation*, in which stormwater performance and/or design stanrdards are met at a location outside the project boundary, typically as arranged by the developer/private entity

- *Stormwater credit trading* or *purchasing* systems in which credits are generated within a defined boundary offsite and then purchased or traded by developers. This mechanism can be well-suited to situations in which numeric criteria for stormwater discharges or so-called pollutant caps have been established.
- *In-lieu fees* in which a fee is paid by onsite developers/property owners to fund storwmater projects elsewhere in the city or watershed

Of these mechanisms, the *fee-in-lieu mechanism* is the most relevant to the approach under consideration by the City of Manhattan, and will be the focus of the remainder of this section. Table A.1 provides a summary of municipalities or other MS4 permit holders that have incorporated a fee-in-lieu program as one of the tools for meeting their post-construction water quality requirements outlined in their MS4 permits. Each of these programs defines a similar set of elements, including:

- Spatial boundaries of the service area within which offsite practices are allowed or prioritized
- Types of offsite practices that are allowed (and who bears responsibility for identifying suitable offsite practices)
- Physical basis of the in-lieu fee and credit ratios

While programs share some similarities in how they have defined each of these elements, there is no single model program structure that fits all programs. For example, programs differ in the definition of the service area in which offsite BMPs may be implemented, with some programs favoring sites within the boundaries of the MS4 permitee (e.g., cities under West Virginia's Phase II general permit) while others require implementation within the same or neighboring watershed to which the development project will discharge (e.g., Wichita, KS; St. Paul, MN; Holly Springs, NC). Programs may also differ in the types of offsite BMPs that may be implemented through an in-lieu fee for stormwater compliance.

For example, the City of St. Paul, MN requires that in-lieu fees *must* be applied to creation of a new structural stormwater BMP or retrofitting an existing structural stormwater BMP as part of a public stormwater project (MPCA, 2018). The City of Holly Springs, NC also requires that in-lieu fees be applied to public stormwater projects; however, implemented stormwater measures may be structural (e.g., bioretention) or non-structural (e.g., riparian buffer restoration) in nature.

A majority of fee-in-lieu of stormwater compliance programs identified through this review stipulate that collected fees must be applied to public stormwater projects. With this requirement comes a greater level of involvement from the municipality/MS4 permit holder as they must play a role in identifying suitable public projects. By contrast, the two programs with fee-in-lieu programs in Kansas – the Cities of Wichita and El Dorado – have allowances to work with rural land managers in upstream or adjacent watersheds to implement water quality practices. In these programs, the municipality/MS4 permit holder relies on an outside partner (e.g., conservation district, watershed management program) to recruit land owners/operators to implement new conservation practices within the approved offsite service area and to then make payments to those land owners/operators according to an agreed upon payment schedule.

Finally, the physical basis for fees also differed among programs according to water quality priority pollutants. For example, the City of Wichita's in-lieu fee is driven by the cost to incentivize adoption of no-till and rotational cropping practices to reduce sediment export from fields in the Little Arkansas watershed. Here, the choice of sediment as the physical basis of the fee is in accordance with the sediment TMDL established for the Little Arkansas River. Similarly, other programs adopt priority pollutants identified throught the TMDL process as the physical basis (e.g., Holly Springs, NC and other municipalities within the Neuse or Chesapeake River basins use nitrogen or phosphorus load reductions to determine fees). Programs with a hydrologic-based stormwater management requirement (e.g., retention of the first inch of rainfall on site) may use a runoff volume based fee structure (e.g., California East Contra Costa County, West Virginia).

Whether the pollutant of concern is a constutituent transported by runoff or the volume of runoff, many programs apply credit ratios to account for uncertainty in offsite controls. For example, the City of Wichita requires a 2-to-1 ratio such that calculated sediment load reductions achieved offsite are double that produced at the development site. Guidance from the EPA regarding offsite stormwater program development notes that the credit ratio can be a critical component to the program's success and that, while important to account for uncertainty, setting the credit ratio too high can make the program economically infeasible to developers (EPA, 2018). This same guidance notes that credit ratios can be applied strategically to incentivize offsite practice implementation in environmentally-sensitive or economically-disadvantaged locations within the defined service area.

Table A.1.1. *Summary programs in which municipalities have utilized offsite BMP programs to meet water quality targets in which offsite BMPs are implemented in rural areas.*

MS4 permit hoder	Need for offsite program	Provider of offsite treatment	Indicators of success	Source of fee payment	Fee basis
City of Wichita, KS (Phase I)	address TSS TMDL in Little Arkansas watershed*	Agricultural landowners/ operators in Little Ark watershed implment BMPs	Types and extent of new conservation practice adoption (e.g., no-till acreage)	Developer / Property owner via annual fee	TSS-load based (2:1 offsite-to-onsite ratio)
City of El Dorado, KS (Phase II)	address water quality in El Dorado Lake and Walnut River (TP and DO)*	rural landowners/ operators in Walnut River watershed in Butler County; City of El Dorado WWTP facility	Number and extent of offsite BMPs; monitoring of TMDL waterbodies	Developer / Property owner	unknown
Holly Springs, NC (Phase II)	Flexibility for new and redevelopment sites to meet nutrient load targets in critical watersheds	City and/or NC Ecosystem Enhancement Program; funds structural and non-structural BMPs in town's watersheds	Estimated nutrient reductions achieved by in-lieu projects	Developer / Property owner via one-time fee	Nitrogen and phosphorus, with additional weighting by impervious surface cover

California East Contra Costa County Municipal Stormwater Permit (Phase I)	Provide flexibility when stormwater management requirements cannot be met completely on-site	fees fund Regional off-site stormwater projects in same watershed as Regulated Project	demonstrate "net environmental benefit" of Regional Project	Developer	equivalent quantity of stormwater runoff and pollutant loading, proportional to O&M costs of Regional Project
St. Paul, Minnesota (Phase I)	Provide flexibility when post-construction BMPs cannot be implemented cost-effectively	Public stormwater projects. Must be structural stormwater BMP, either new or retrofit of existing	Documentation of BMP implementation and maintenance plan	Owner and/or operator of a construction activity	Cost to build new or retrofit existing public stormwater project
New Mexico Middle Rio Grande Watershed (Phase I and II permittees)	Provide flexibility when post-construction BMPs are constrained by site conditions	Fees paid to MS4 permit holder to be applied to public stormwater project	MS4 maintains publically accessible database of approved public projects to which fees have been applied	Owner and/or operator of a construction activity	Not given
West Virginia Dept. of Environmental Protection (Phase II)	Provide flexibility to constrained sites and infill development; cost-effective means for equal or better runoff reduction	Fees paid to MS4 permit holder to be applied to public stormwater project	MS4 maintains publically accessible database of approved public projects to which fees have been applied	Owner and/or operator of a construction activity	Cost to build new public stormwater project to capture equivalent runoff from 1-inch rainfall at a 1.5:1 to 2:1 ratio.

*Abbreviations for TMDL pollutants of concern: TSS (total suspended sediment), TP (total phosphorus), DO (dissolved oxygen),

A.2 State of the Science: Pollutant loads and BMP load reductions in urban and rural contexts

Pollutant Load Estimates

Establishing a baseline for expected pollutant concentrations and loads from urban landuses within the City of Manhattan and conceivable load reductions achieved by water quality BMPs is needed to (1) provide some level of confidence that a Fee in Lieu of Treatment program is contributing to overall watershed quality goals and (2) setting appropriate fees for either annual or one-time payments by properties that opt to participate in the Fee in Lieu of Treatment program. For the purposes of this study, these baseline pollutant loads were determined through the literature, as opposed to direct monitoring, with consideration for soils, landuse, and climate.

The first national assessment of stormwater quality was conducted by the U.S. EPA over four decades ago (U.S. EPA, 1983). Since that time, the number of studies documenting urban stormwater runoff quality has greatly increased and have been analyzed in studies such as Bell et al. (2020) and Simpson et al. (2022).

Bell et al. (2020) applied a regionalization schedme to runoff pollutant concentrations documented in the National Stormwater Quality Database (NSQD). When parsed out by land use and region, they found that over 80% of variability in runoff pollutant concentrations could be explained. Median and interquartile values for common pollutants of concern and of relevance to Manhattan's alternative compliance program are summparized in Tables A.2.1 to A.2.3.

Similarly, Simpson et al. (2022) developed regression equations in which landuse, impervious cover, and climate region were variables; however, instead of relying on reported values in the NSQD, they mined peer-reviewed literature from over 360 urban watersheds across the globe. Their analysis indicated land use and climate exert a greater influence on runoff pollutant concentrations than impervious cover. Regression equations developed in this analysis were applied for the climate region corresponding to Manhattan for commercial, industrial, and residential landuses as reported in Tables A.2.1 through A.2.3.

As indicated in the tables, runoff concentrations compiled in these contemporary studies are still in line with the U.S. EPA's 1983 assessment. Estimates for TN, TP, and TSS runoff concentrations from industrial land uses obtained by Moore (2022) as part of the Joint Maintenance Facility water quality BMP study – which were compiled from an earlier analysis of the NSQD, are also provided in Table A.2.2 for comparison.

General observations from this review of the literature on urban runoff pollutant concentrations include that Simpson et al.'s (2022) meta-analysis generally resulted in higer median pollutant EMC values compared to ranges reported by Bell et al. (2020), though the range in expected values about the event mean (given as 90^{th} percentile confidence interval) and median (given as 25^{th} to 75^{th} quartile range) generally overlap. It can also be observed that nutrient and bacteria concentrations from residential riunoff is predicted to be higher than from industrial or commercial land uses in both studies, potentially reflecting the role of lawn fertilization practices and animal waste (namely dogs) on nutrient and bacteria budgets as was suggested by Hobbie et al. (2017).

Table A.2.1. *Event mean concentration (EMC) for stormwater pollutants associated with* ***commercial*** *land use.* "NR" indicates pollutant was not reported.

Pollutant	**Bell et al. (2020)** median EMC (25% to 75% quartile range)	**Simpson et al. (2022)** EMC (90% confidence interval)	**U.S. EPA (1983)** median EMC (25% to 75% quartile range)
Total Nitrogen	2.17 mg/l (1.46-3.26)	3.05 mg/l (2.74-3.37)	1.75 mg/l
Nitrate	0.47 mg/l (0.32-0.64)	0.73 mg/l* (0.26-1.21)	0.57 mg/l
Ammonia	NR	0.45 mg/l (0-0.91)	NR
Total Phosphorus	0.16 mg/l (0.09-0.27)	0.25 mg/l (0-0.74)	0.20 mg/l
Orthophosphate	0.03 mg/l (0.03-0.08)	0.17 mg/l (0-0.62)	0.08 mg/l
Total suspended solids	36 mg/l (19-64)	96.6 mg/l* (96-97)	69 mg/l (30-110)
Fecal coliform bacteria	9000 CFU/100 ml (1850-3000)	NA	21,000 CFU/100 ml

*equation upon which concentration based had poor fit ($R^2 < 0.3$) and is considered highly uncertain

Table A.2.2. *Event mean concentration (EMC) for stormwater pollutants associated with* ***industrial*** *land use.* "NR" indicates pollutant was not reported.

Pollutant	**Bell et al. (2020)** median event mean conc. (25% to 75% quartile range)	**Simpson et al. (2022)** event mean concentration (90% confidence interval)	**Moore (2022)** event mean conc.
Total Nitrogen	2.21 mg/l (1.61-2.87)	2.79 mg/l (2.47-3.10)	2.5 mg/l
Nitrate	0.53 mg/l (0.35-0.77)	0.82 mg/l* (0.35-1.3)	NR
Ammonia	NR	0.16 mg/l (0-0.62)	NR
Total Phosphorus	0.19 mg/l (0.12-0.325)	0.31 mg/l (0-0.8)	0.29 mg/l
Orthophosphate	0.03 mg/l (0.03-0.09)	0.2 mg/l (0-0.64)	NA
Total suspended solids	82 mg/l (51-154)	133 mg/l* (132-134)	75 mg/l
Fecal coliform bacteria	7700 CFU/100 ml (1200-19250)	NR	NR

*equation upon which concentration based had poor fit ($R^2 < 0.3$) and is considered highly uncertain

Table A.2.3. *Event mean concentration (EMC) for stormwater pollutants associated with* **residential** *land use.* "NR" indicates pollutant was not reported.

Pollutant	**Bell et al. (2020)** median EMC (25% to 75% quartile range)	**Simpson et al. (2022)** EMC (90% confidence interval)	**USEPA (1983)** median EMC (25% to 75% quartile range)
Total Nitrogen	2.86 mg/l (2.07-3.6)	4.1 mg/l (3.78-4.41)	2.64 mg/l
Nitrate	0.4 mg/l (0.33-0.56)	1.01 mg/l* (0.53-1.48)	0.73 mg/l
Ammonia	NR	0.47 mg/l (0.01-0.93)	NR
Total Phosphorus	0.35 mg/l (0.24-0.54)	0.42 mg/l (0-0.92)	0.38 mg/l
Orthophosphate	0.07 mg/l (0.04-0.15)	0.18 mg/l (0-0.63)	0.14 mg/l
Total suspended solids	80.5 mg/l (43.3-148)	113 mg/l* (112-114)	101 mg/l (60-270)
Fecal coliform bacteria	23,000 CFU/100 ml (6975-68500)	NR	21,000 CFU/100 ml

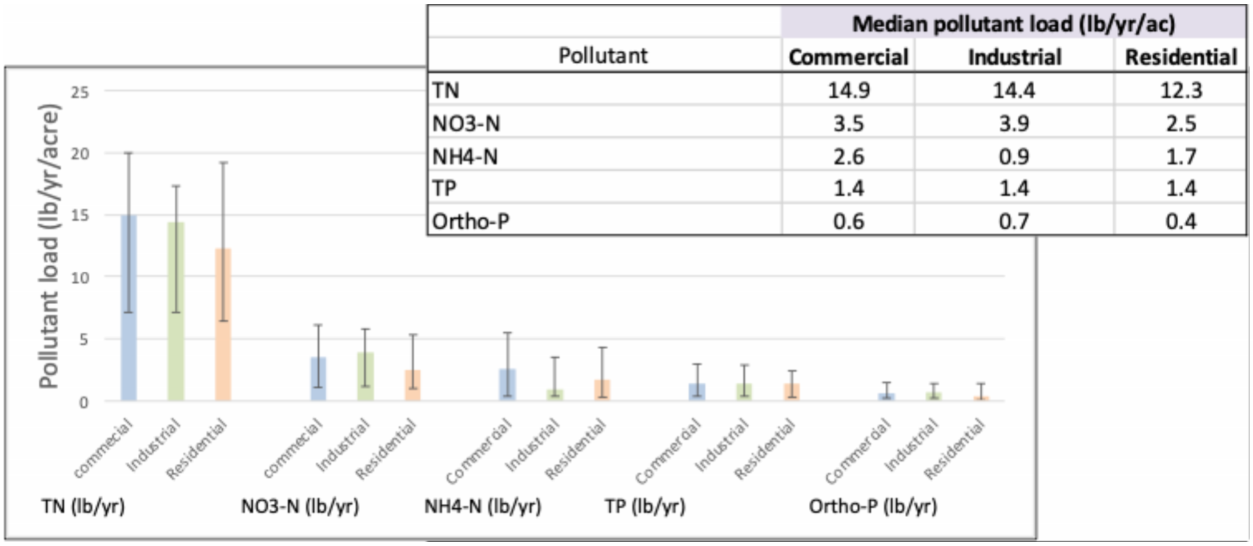
*equation upon which concentration based had poor fit ($R^2 < 0.3$) and is considered highly uncertain

TMDLs and other stormwater compliance programs involving pollutant trading or credit systems generally deal in terms of pollutant loads over a set time period (e.g., year); thus, it is instructive to translate expected runoff concentrations to pollutant loads.

The concentrations given in Tables A.2.1 through A.2.3 are event mean concentrations, which can be converted to mean annual loads by multiplying by mean annual runoff volume.

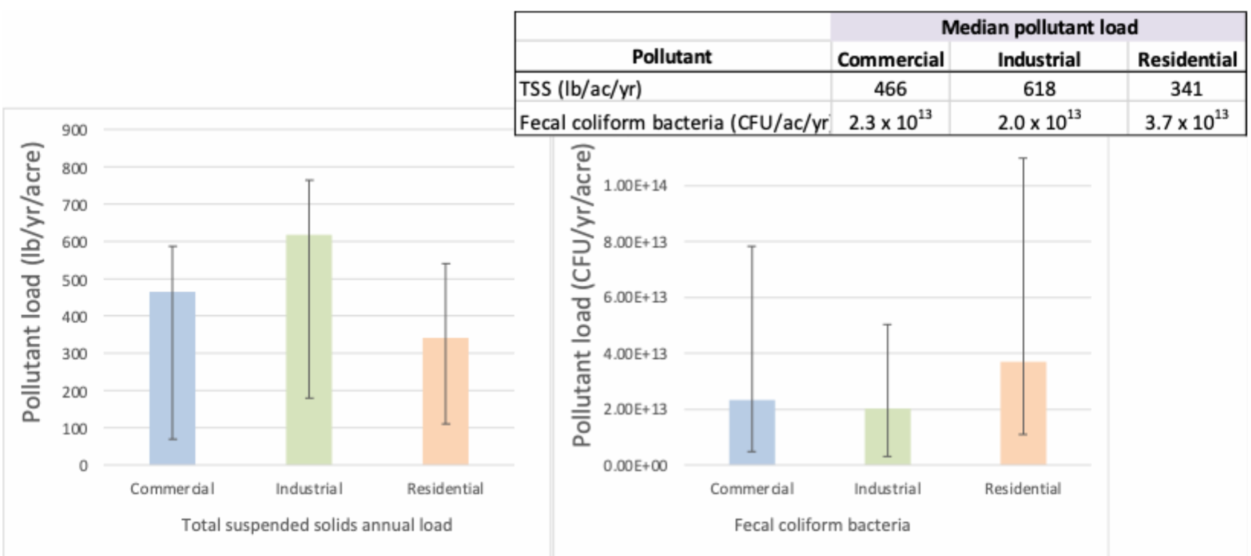
The annual runoff volume is a function of annual precipitation (mean value is 34.7 inches for Manhattan, KS) and watershed characteristics such as slope, soil condition, and impervious cover. For the purpose of calculating runoff volume to convert runoff concentrations into loads in the context of Manhattan, Kansas, the "Simple Method" for urban runoff volume proposed by Schueler (1987) was adopted. Impervious cover is a primary predictor variable in this method, reflective of the strong correlation observed between impervious surface area and runoff volume from urban watersheds. Here, impervious cover of 85%, 75%, and 35% was selected for commercial, industrial, and residential land covers for consistency with the impervious cover specified in the City of Manhattan's Stormwater Criteria Manual (2023). The bar charts presented in Figures A.2.1 and A.2.2 display median nutrient and sediment loads, respectively, as calculated from concentrations compiled from the literature review for commercial, industrial, and residential land uses. The bars on the charts represent the 25th and 75th percentiles and thus demonstrate the variability inherent pollutant runoff processes and resulting loads. Even with this variability, the median calculated load was selected for estimating the pollutant load generated by various types of development in Manhattan.

In reality, impervious cover is expected to vary from site to site within the same development type. To account for differences in imperviousness of properties that opt to participate in the alternative stormwater compliance program, we define an *equivalent commercial acre* (ECA) as a baseline for establishing the "demand side" for pollutant credits from the program and then scaling factors based on a development's actual impervious cover. An ECA is defined as 1 acre of commercial development with 85% impervious cover. These recommendations for translating variable pollutant loads from various urban land uses to a pollutant load that sets the "demand" for this program are presented in Appendix A.4.



Pollutant	Median pollutant load (lb/yr/ac)		
	Commercial	Industrial	Residential
TN	14.9	14.4	12.3
NO3-N	3.5	3.9	2.5
NH4-N	2.6	0.9	1.7
TP	1.4	1.4	1.4
Ortho-P	0.6	0.7	0.4

Figure A.2.1. *Estimated annual nutrient loads for commercial, industrial, and residential land use types. Median values are shown by the bars and table; upper and lower error bars represent 25th and 75th quartiles according to corresponding quartile range in runoff nutrient concentrations and impervious surface cover. Impervious cover was assumed as 85% for commercial and industrial and 50% for residential. All loads on a per acre basis. Data from USEPA (1983), Bell et al. (2020), Simpson et al. (2022), and Moore (2022).*



Pollutant	Median pollutant load		
	Commercial	Industrial	Residential
TSS (lb/ac/yr)	466	618	341
Fecal coliform bacteria (CFU/ac/yr	2.3×10^{13}	2.0×10^{13}	3.7×10^{13}

Figure A.2.2. *Estimated annual total suspended solids (left panel) and fecal coliform bacteria (right panel) from commercial, industrial, and residential land use types assuming Manhattan's mean annual rainfall (34.7 inches). Median values are shown by the bars and in the table; upper and lower error bars represent 25th and 75th quartiles according to corresponding quartile range in runoff nutrient concentrations. Impervious cover was assumed as 85% for commercial and industrial and 50% for residential. All loads are presented on a per acre basis. Data from USEPA (1983), Bell et al. (2020), Simpson et al. (2022), and Moore (2022).*

BMP Load Reduction Estimates, Urban Practices

The preceding consideration of urban pollutant concentrations and loads reflects some of the most recent work by the research community to understand the influence of land use and geographic region (and associated climate patterns) on stormwater pollutant generation. There has also been recent work to characterize potential pollutant load reductions by various types of stormwater control measures, including green stormwater infrastructure, in urban environments as well as soil and water conservation practices in agricultural landscapes. This collection of practices will be referred to herein as best management practices (BMPs), with urban BMPs denoting practices applied in urban landscapes and rural BMPs denoting practices in landscapes with low population density and high degree of cropping and/or grazing food production systems. In the following section, the state of the science on pollutant load reduction potential by both urban and rural BMPs is presented.

With respect to urban BMPs, Bell et al. (2020) provide one of the most thorough contemporary analyses of BMP performance through analysis of BMP performance documented in the International Stormwater BMP Database (Clary et al., 2007). Regional considerations were overlain on this analysis by assigning each BMP performance dataset to one of EPA's "Rain Zones." From this analysis, Bell et al. (2020) report percent removal efficiencies as determined as the relative difference between the influent concentration (C_{in}) and concentration leaving the BMP (C_{out}) as described in Equation 1:

$$\textit{Removal efficiency}\ (\%) = (C_{\text{in}} - C_{\text{out}})/C_{\text{in}} \qquad (\textit{Equation 1})$$

Median percent pollutant removals reported by Bell et al. (2020) are presented for a set of common urban BMPs in Table A.2.4. We acknowledge that % removal efficiency is a relative metric and tends to be higher for those cases in which C_{in} is higher and, therefore, clouds comparisons between BMPs.

We also note that the International Stormwater BMP Database from which these data were obtained does not necessarily reflect performance of BMPs that meet best practices for design, construction and/or maintenance. For example, a bioretention system that follows best practice design recommendations for a saturated denitrification zone and media with low labile nutrient content can be expected to achieve much higher nitrate and total nitrogen removals than reflected in Table A.5 (e.g., > 70%; NCDEQ, 2017). Well-designed constructed stormwater wetlands have also been reported to reduce nitrate concentrations near-zero and total nitrogen concentrations by about 50% on average (NCDEQ, 2017). Nonetheless, the systems represented in the BMP Database may be more reflective of an actual population of stormwater BMPs including both high and low performers.

***Table A.2.4**. Common urban BMPs and corresponding median pollutant load reductions (range bounded by 25th to 75th quartile given in parentheses) as analyzed from the International Stormwater BMP Database by Bell et al. (2020).*

Pollutant	Underground Detention	Constructed Wetland	Bioretention	Wet Detention	Dry Detention	Grass Swale
Total Nitrogen (mg/l)	-5% (-18% to 61%)	3% (-1% to 15%)	29% (0% to 34%)	22% (5% to 39%)	7% (-17% to 30%)	3% (-28% to 26%)
Nitrate (mg/l)	52% (20% to 72%)	3% (-18% to 27%)	-190% (-460% to -69%)	-63% (-135% to -10%)	26% (-10% to 58%)	0 (-50% to 45%)
Total Phosphorus (mg/l)	-11% (-42% to 7%)	23% (0% to 44%)	-30% (-167% to 21%)	60% (30% to 76%)	14% (-14% to 33%)	-14% (-100% to 24%)
Orthophosphate (mg/l)	3% (1% to 9%)	-3% (-53% to 23%)	-210% (-360% to -80%)	52% (-15% to 77%)	-6% (-30% to 28%)	-45% (-120% to 0)
Total suspended solids (mg/l)	55% (19% to 76%)	46% (8% to 67%)	94% (75% to 98%)	82% (62% to 91%)	68% (28% to 79%)	29% (-38% to 61%)
Fecal coliform bacteria (CFU)	16% (-70% to 26%)	12% (-9% to 49%)	-28% (-200% to 28%)	70% (12% to 93%)	23% (-25% to 38%)	-33% (-100% to 69%)

BMP Load Reduction Estimates, Agricultural Practices

The water quality benefits of water and soil conservation practices in rural settings continues to be an active research area. These practices include those that are structural in nature – for example, terrace and waterway systems or constructed sediment basins and ponds – as well non-structural practices such as cover crops and vegetated buffers (Table A.2.5).

While the International Stormwater BMP database has spearheaded initiatives to incorporate agricultural BMPs, the total number of studies for individual practices remains low. Thus, we supplemented water quality data for agricultural BMPs compiled in the International Stormwater BMP Database with a literature review including studies that were not already part of the BMP database (Carver et al., 2022; CBP, 2022; Faust et al., 2018; Koropeckyj-Cox et al., 2021; Tomer and Locke, 2011. Ranges of percent removals for a set of cropland and grazing system BMPs are provided in Table A.2.5. As stated for urban stormwater BMPs, percent removals reported for BMPs in agricultural systems are also sensitive to the influent concentrations. Influent concentrations depend on cropping system rotations, soil type and slope, existing management practices, and a number of other environmental and management factors.

We provide estimates of runoff concentrations from cropland and grazing systems more specific to conditions in candidate offsite service area (see Section A.3) as part of the analyses in Section A.4, and we apply median percent removals presented in Table A.2.6 to these local runoff loads in that section as well.

Table A.2.5. *Descriptions of BMPs considered in the "menu" of options for providing sediment credits in cropland and grazing systems.*

Cropland baseline: conventional tillage. Tillage implements overturn soil prior to planting and leave less than 10% residue cover after planting. Bare soil is susceptible to erosion, particularly between growing seasons when soil surface is exposed. Repeated soil disturbance breaks down soil structure, increases mobility of nitrogen, and decreases organic matter content.	
Cropland BMPs and description	
No-till adoption	Crops are planted with a drill or in narrow seedbeds or slots created by coulters, disk openers or row cleaners such that soil is surface is undisturbed. Promotes soil structure and maintains residue from previous crop to protect soil surface and reduce sediment detachment and erosion. Other soil health indicators associated with no-till adoption include increased organic matter accumulation, infiltration, and water holding capacity. However, in the absence of tillage, increased reliance on herbicides to control weeds is common. *Therefore, additional incentive payments for herbicide management best management practices are desired and are included in cost considerations.*
Cover crop adoption	Grasses, legumes and/or forbs planted for seasonal cover to reduce soil erosion and promote overall soil health. Covers may undergo frost kill in winter or herbicide kill prior to planting crop. Greater benefits accrue the longer the cover crop is living. As with no-till adoption, *additional incentive payments for herbicide management best management practices are desired and are included in cost considerations.*
Terrace-waterway system rehabilitation	Terraces are an earthen embankment or ridge built across a slope (on the field contour) to slow surface runoff. Sets of terraces typically outlet to a grass waterway, which conveys runoff from the field and can provide additional water quality treatment. Fields requiring terracing in Riley County have largely been addressed; however, some terrace systems have not been maintained and require rehabilitation to provide erosion control benefits. Terrace design described by USDA NRCS (2011).
Vegetated buffer establishment	Permanent vegetation (trees and/or native grasses) are established in buffer area along rivers, tributaries, and other drainage ways. NRCS standards for riparian buffers establish a minimum buffer width of 35 ft. To receive water quality credit, buffer areas should not be disturbed by tillage, planting or grazing activities (note that this is counter to allowance for agricultural activities within riparian buffer zones described by local ordinances, such as the Riley County Land Development Regulations (2022).
Grazing baseline: **livestock with full access to riparian area and waterways.** Livestock have unrestricted access to ephemeral and/or perennial waterways in the pasture, resulting in trampling of riparian vegetation and streambank and direct deposition of urine and feces in the waterway.	
Grazing BMPs and description	
Stream, riparian buffer exclusion	Exclusion of livestock from riparian areas and, in particular, from direct contact with waterways with fencing prevents direct deposition of manure (nutrients, bacteria) in waterways and promotes robust riparian vegetation with greater retention/removal of sediment and nutrients. Often requires establishment of alternative water source.

Table A.2.6. *Median percent removals documented for BMPs in cropland and grazing systems. Range is given in parentheses.*

Pollutant	No-till	Cover crops	Terrace and waterways	Grass buffer, cropland	Grass buffer, grazing [1]
Total Nitrogen	15% (10 to 60%)	20% (10% to 25%)	15% (0% to 20%)	24% (20% to 24%)	30% (20% to 40%)
Total Phosphorus	20% (0% to 50%)	10% (0% to 28%)	20% (10% to 25%)	30% (20% to 50%)	30% (8% to 90%)
Total suspended sediment	70% (41% to 79%)	70% (60% to 80%)	50% (10% to 90%)	30% (10% to 55%)	50% (30% to 61%)

[1] percent removal for grass buffer in grazing system is assumed to be paired with exclusion fencing to prevent entry by livestock

A.3. Local watershed assessment: water quality threats and opportunities

The project team and City of Manhattan stormwater staff identified candidate watershed areas in which offsite BMPs could be implemented as part of an alternative stormwater compliance program. Attributes of selected watershed areas include (1) within Riley County or near city service areas in adjacent Pottawatomie County and (2) drain to water bodies with documented water quality impairments and associated Total Maximum Daily Loads (TMDLs). Watersheds with these characteristics were desirable such that funds generated through the alternative compliance program would be targeted to areas near to Manhattan and to water quality improvements in impaired waters. Figure A.3.1 highlights identified watersheds, including watersheds draining to Tuttle Creek Reservoir (Fancy Creek, Swede Creek-Big Blue River, and Tuttle Creek Lake), Wildcat Creek, and the Kansas and Big Blue downstream of Tuttle Creek. The current status of these watershed areas, as well as opportunities for water quality enhancements, is discussed in the following subsections.

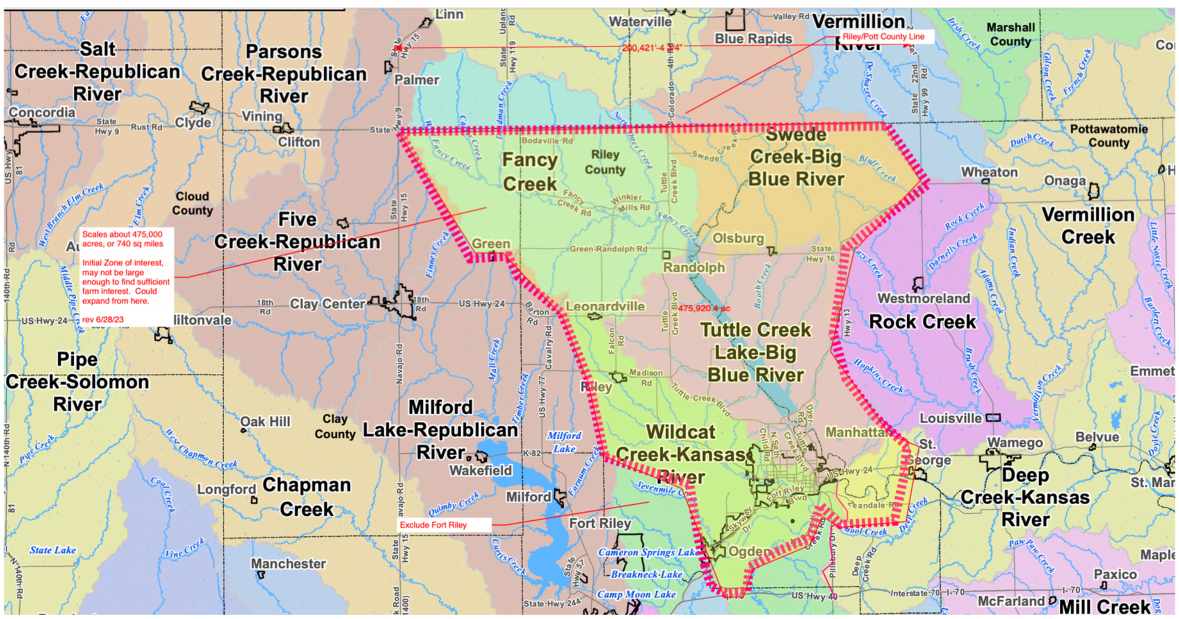


Figure A.3.1. *Candidate watershed areas for offsite BMPs implemented through an alternative stormwater compliance program in the City of Manhattan.*

(Note: The watershed boundaries shown above were identified as part of the initial version of this memo. During subsequent discussions with potential land managers in the region, it was suggested we add additional areas that drain to Tuttle Creek but are north of the limits shown, in Washington and Marshall Counties. The reasons given include current level of conservation attention and activity from past EPA prioritization of watersheds to protect Tuttle Creek. It is recommended that the City and KDHE consider such an expansion as the detailed plans for implementation are developed.)

A.3.1. Tuttle Creek Lake tributary areas in Riley and Pottawatomie Counties

Tuttle Creek Reservoir drains over 9,600 square miles, including tributaries of the Big Blue extending into Nebraska. For the purposes of a Fee in Lieu of Treatment stormwater program for the City of Manhattan, only the portion of the drainage area within Riley and Pottawatomie Counties, which encompasses about 370 square miles primarily comprised of pasture/grazing land (54%), cropland (20%) and woodland (19%), is considered. (Revision Note: as indicated above, the City and KDHE may want to consider expanding the focus area for Tuttle Creek protection further north to includes portions Washington and Marshall Counties.)

Tuttle Creek Reservoir is listed as impaired for eutrophication, siltation, and the herbicide atrazine, all of which are considered a "high" priority (KDHE, 2022). Together, these pollutants impair the reservoir for its designated uses of water supply and supporting expected aquatic communities. TMDL documents outline sets of desired implementation activities to address this set of pollutants (KDHE 2000a; 2000b; 2000c). These include:

- Reducing nutrients and bacteria at the source: soil testing and manure/fertilizer management on cropland; implement pesticide best management practices; limit development and disturbance within riparian areas
- Reduce pollutant loss from agricultural systems: implement reduced tillage on cropland; enhance or restore riparian vegetation
- Reduce pollutant loss from urban systems: facilitate urban and construction stormwater management from urban development, including in Riley and Pottawatomie Counties and City of Manhattan using stormwater BMPs; minimize road and bridge construction on streams

The Tuttle Creek WRAPS organization was established in 2010 and continues to provide leadership and coordination to implement these and other water quality practices throughout the Tuttle Creek Watershed, including areas within Riley County (WRAPS, 2018).

A.3.2. Big Blue River downstream of Tuttle Creek Lake

The segment of the Big Blue River flowing from Tuttle Creek Lake to its confluence with the Kansas River is currently listed as imparied for both total phosphorus (TP) and fecal coliform bacteria (KDHE, 2022). Together, these pollutants impair uses of the Big Blue River for contact recration, domistic water supply, and aquatic life.

The drainage area to this segment of the Big Blue is approximately 54 square miles. General landuse includes cropland (13%), pasture/grazing land (55%), urban development (11%) and woodland (18%). Impervious surfaces (e.g., roads, building rooftops) comprise approximately 6% of the drainage area.

This segment of the Big Blue River is part of the Middle Kansas Watershed and, as such, the Middle Kansas WRAPS plays a large role in coordinating efforts to address nonpoint source pollution. The TMDL documents (KDHE, 2016; KDHE, 2000d) for TP and fecal coliform bacteria outline a complementatry set of practices to improve overall water quality in this watershed, including:

- Reducing nutrients and bacteria at the source: soil testing and manure/fertilizer management on cropland; urban homeowner nutrient reduction practices through stormwater management programs
- Reduce pollutant loss from agricultural systems: implement conservation tillage on cropland and pasture management practices in grazing lands to improve soil health and reduce runoff; alternative feeding and watering systems to limit livestock access to waterbodies; enhance or restore riparian vegetation
- Reduce pollutant loss from urban systems: facilitate urban and construction stormwater management from urban development, including in Riley and Pottawatomie Counties and City of Manhattan using stormwater BMPs

A.3.3. Kansas River between Ogden and St. George

As with the Big Blue downstream of Tuttle Creek Lake, the segment of the Kansas River flowing in the Manhattan vicinity through Riley and Pottawatomie Counties between Ogden and St. George is currently listed as imparied for both total phosphorus (TP) and fecal coliform bacteria (KDHE, 2022). Together, these pollutants of concern impair uses of the Kansas River for contact recration, domistic water supply, and aquatic life.

The drainage area to this segment of the Kansas River is 140 square miles in total, with 39 square miles occupied by Fort Riley Military Base. General land uses across the remaining 101 square miles include cropland (26%), pasture/grazing land (25%), woodland (27%), and urban development (17%). Impervious surfaces (e.g., roads, building rooftops) comprise approximately 10% of the drainage area. Stormwater runoff from Manhattan, Kansas and nearby unincorporated areas in both Riley and Pottawatomie Counties discharges to this segment of the Kansas River and is permited by KDHE through the MS4 program (KDHE, 2016; KDHE, 2000b). In addition, the City of Manhattan operates 1 of 17 wastewater treatment plants (WWTP) that discharge to the Kansas River between Ogden and Wamego. Given high phosphorus levels and associated impairments documented in the Kansas River, the Manhattan WWTP has been assigned a waste load allocation of 1 mg total phosphorus (TP) per liter (KDHE, 2016). The city invested in advanced aerobic biological nutrient removal technology in 2014, and, since that time, has maintained average total phosphorus concentrations of 0.57 mg TP/L, which is about 40% lower than its waste load allocation. Stormwater runoff from Manhattan, Kansas and nearby vicinity in both Riley and Pottawatomie Counties also discharges to impaired segments of the Kansas River.

Given similarities in water qulaity impairments and land use between this segment of the Kansas River and Big Blue River discussed in Section A.3.2, the same set of water quality practices identified in KDHE TMDL documents applies (KDHE, 2016; KDHE, 2000d). As with the Big Blue downstream of Tuttle Creek, the Middle Kansas WRAPS plays a major role in providing leadership and coordinating pollutant reduction practices in both cropland (e.g., conservation crop rotations) and grazing systems (vegetated filter strips, off-stream water and feeding sites).

A.3.4. Wildcat Creek Watershed

Wildcat Creek and its tributary network are currently listed as imparied for both dissolved oxygen (DO) and fecal coliform bacteria (KDHE, 2022). Together, these pollutants impair designated uses throughout the creek network for supporting expected aquatic life as well as for primary and secondary contact recreation. While the fecal coliform impairment is fairly straightforward, the DO impairment is more nuanced as it arises primarily during the summer and fall, particulary during low flow conditions, and is likely the outcome of nutrient and organic loads from nonpoint sources (KDHE, 2000e, 2000f).

The Wildcat Creek watershed encompasses nearly 100 square miles at its confluence with the Kansas River in Manhattan. Of this, 34 square miles lies within the Fort Riley military base and is not considered further as a candidate area for an alternative stormwater compliance program. General landuse in the remaining 66 square miles of the watershed includes cropland (32%), pasture/grazing land (40%), woodland (16%) and urban development (12%). Impervious landcover (e.g., roads, building rooftops) comprises approximately 4% of the drainage area.

The Wildcat Creek watershed also falls within the Middle Kansas Watershed and, thus, the Middle Kansas WRAPS is expected to play a large role in coordinating water quality practices within this watershed. The same practices as identified for the Big Blue and Kansas Rivers (Sections A.3.2 and A.3.3) should be applicable in Wildcat Creek given similarities in land use types and priority pollutants (fecal coliform bacteria, nutrients). In its most recent EPA 9 Element Plan, the Middle Kansas WRAPS designates Wildcat Creek as a future priority area in the 2035 to 2040 time period; thus, it is likely that a majority of current WRAPS efforts are focused in other priority areas of the watershed (WRAPS, 2011).

A.4. Recommendations for Fee-in-Lieu Program Framework

Here, we provide a draft framework for an alternative compliance stormwater quality program. It is expected that the framework will evolve as additional information is collected over the course of the program. Even so, this framework can serve as a foundation for building a program with flexibility to target various practices to address unique water quality concerns within the target watershed service area within feasible program technical and administrative structures.

Recommendations are presented for each of the following program elements: spatial bounds of the program (A.4.1), stormwater pollutant loading rates ascribed to new and redevelopments within the City of Manhattan (A.4.2), a pollutant credit ratio applied to properties opting to participate in the offsite program (A.4.3), offsite (i.e., cropland and grazing system) BMPs that are feasible to implement (A.4.4), pollutant reduction credits that can be ascribed to potential offsite BMPs (A.4.5), key watershed partners and their role in program implementation and administration (A.4.6), and recommendations for tracking program implementation and effectiveness (A.5.7).

A.4.1. Spatial bounds of the program

The spatial bounds of the program refer to the service area outside the City of Manhattan boundaries in which offsite BMPs may be implemented. This area was identified through discussion with KDHE. Primary considerations for selecting the watersheds to comprise the offsite service area included (1) documented water quality issue including, for example, TMDL and listed 303(d) streams; (2) in Riley County or region of city growth in neighboring Pottawatomie County; (3) outside of Fort Riley military base; and, critically, (4) support from KDHE. The recommended service area is discussed in the previous section, including a summary of watershed characteristics, water quality challenges, and opportunities to address for each of the watershed areas delineated in Figure A.3.1. These boundaries establish the geographic boundaries within which offsite measures can be implemented. (As noted though, the City and KDHE may want to consider expansion of the service to the north as discussed when making final program arrangements).

A.4.2. Stormwater pollutant loading rates within the City of Manhattan

The review of recent work to characterize stormwater runoff pollutant loads presented in Section A.2 provides a scientific basis for ascribing pollutant loads to runoff from new and redevelopment properties within the City of Manhattan. As was evident from this review, stormwater pollutant loadings are highly variable across time and space; however, there is precedent for stormwater fee-in-lieu programs such as being considered by Manhattan to develop a professional judgement of pollutant loads based on best literature estimates (e.g., Cities of Wichita, KS and Holly Springs, NC; see Section A.1). Drawing from experience of the offsite stormwater program administered by the City of Wichita, KS, it is anticipated that Manhattan's fee in lieu program will be most frequently used by smaller (e.g., up to 5 acres) commercial development and redevelopment projects for which space constraints limit effectiveness of tradiational urban stormwater BMPs. Accordingly, we recommend developing an estimate for a "typical" commercial/industrial development type with a baseline impervious cover (85%, consistent with the impervious cover used in the City of Manhattan's Stormwater Guidance Manual to describe commercial areas) and assuming low infiltrating soils. For the purposes of this program, this "typical" commercial development type is the basis of an *Equivalent Commercial Acre* (ECA) – a one-acre, 85% impervious commercial development – recommended as the accounting unit for the sediment and/or other pollutant "demand" generated by properties that opt to participate in the fee-in-lieu program and which will require offset via offsite BMPs.

The annual load from 1 ECA was determined by multiplying median pollutant load concentrations obtained from the literature (e.g., Figure A.2.2) by the annual runoff generated by a 1-acre, 85% impervious area. The annual runoff volume was estimated by applying Schuler's (1987) "Simple Method" to the mean annual precipitation recorded for Manhattan, Kansas (34.7 inches over the past 30-years of record), which resulted in a mean annual runoff estimte of 25.4 inches. Resulting annual loads are presented in Table A.4.1.

While we recognize the ecological significance of dissolved inorganic nutrient forms (e.g., nitrate, orthophosphate), we recommend starting with a simplified set of pollutants representing sediment (TSS), nitrogen (TN) and phosphorus (TP). Fecal coliform bacteria concentrations and loads are also included given related TMDLs in watersheds considered within the service area (Sections A.3 and A.4.1). While the values presented in Table A.4.1 are best estimates, they are consistent with measured annual loads in multi-year urban watershed field studies reported by Hobbie et al. (2017) and Porter (2022).

Table A.4.1. *Baseline pollutant loads for 1 Equivalent Commercial Acre and low infiltrating soils. Mean annual runoff (25.4 inches) was estimated using the "Simple Method" for urban runoff calculation (Schuler, 1987) given Manhattan's mean annual rainfall (34.7 inches) for a 1-acre, 85% impervious drainage area. Relevant conversion factors include 3,630 cubic ft of runoff volume for each 1-inch of runoff over an acre, 453.592 grams/lbs, 28.3168 liters per cubic foot, and thus 1.0 lbs/cubic ft is the equivalent of 16,018 mg/L*

Pollutant	Concentration	Annual Load
Total suspended solids	81 mg/l	466 lb/yr/acre
Total Nitrogen	2.6 mg/l	14.9 lb/yr/acre
Total Phosphorus	0.25 mg/l	1.44 lb/yr/acre
Fecal coliform bacteria	9,000 CFU/ml	2.3 x 10^{13} CFU/yr/acre

To determine the total suspended solids annual load result in the above table as an example:

*(81 mg/L) * (1 lb/cf per 16,018 mg/L) * 25.4 inches/yr of net runoff from a single ECA * 3,630 cu ft per inch-acre = 466 lb/yr/acre*

The TN and TP would be calculated in a similar manner. For the Fecal coliform bacteria, the example would be:

*(9,000 CFU/ml) * (28,316 ml/cf) * 25.4 inches/yr of net runoff from a single ECA*
** 3,630 cu ft per inch-acre = 2.34 * 10^13 CFU/yr/acre*

The loads presented in Table A.4.1 can be scaled to represent development types that differ from the ECA defined herein. Since a primary driver of the pollutant load calculation is impervious area, we recommend basing this scale on the percentage impervious cover. As demonstrated in Section A.2, pollutant concentrations and loads can be expected to differ somewhat among land uses, with residential land uses diverging somewhat from commercial and industrial land uses, particularly with respect to total nitrogen and phosphorus concentrations. Table A.4.2 provides recommended scaling factors for adjusting the sediment load defined for an ECA to reflect developments with differing levels of impervious cover. While sediment is recommended as the primary pollutant tracked in the alternative compliance program given its universal impact to TMDL waters surrounding Manhattan, the same approach can be taken to scale total nitrogen and phosphorus. In the case of nutrients, prior studies indicate loadings differ among urban land uses, with residential areas generally producing higher nitrogen and phosphorus load compared to commercial areas. Accordingly, figure A.4.1 illustrates how scaling factors that could be applied to the pollutant loads presented in Table A.4.1 as a function of both development type (residential versus commercial/industrial) and total impervious surface cover. Note that the minimum threshold for this impervious-based scaling approach is 5% for all pollutants. This was done to recognize the pollutant impact that urban lawn contributes relative to undisturbed (e.g., in terms of soils) vegetated areas remaining on site following development and is consistent with the threshold impervious area within residential developments at which aquatic ecosystem impacts have been observed (Booth and Jackson, 1997).

Table A.4.2. Scaling factors to be applied to developments to determine sediment load generation on the basis of total impervious cover of the development relative to the equivalent commercial area (ECA).

Impervious surface cover	**ECA scaling factor (ECAs/acre)**	**Impervious surface cover**	**ECA scaling factor (ECAs/acre)**
< 5%	0.1	55.1% to 65%	0.7
5.1% to 15%	0.2	65.1% to 75%	0.9
15.1% to 25%	0.3	75.1% to 85%	1.0
25.1% to 35%	0.4	85.1% to 95%	1.1
35.1% to 45%	0.5	> 95%	1.2
45.1% to 55%	0.6		

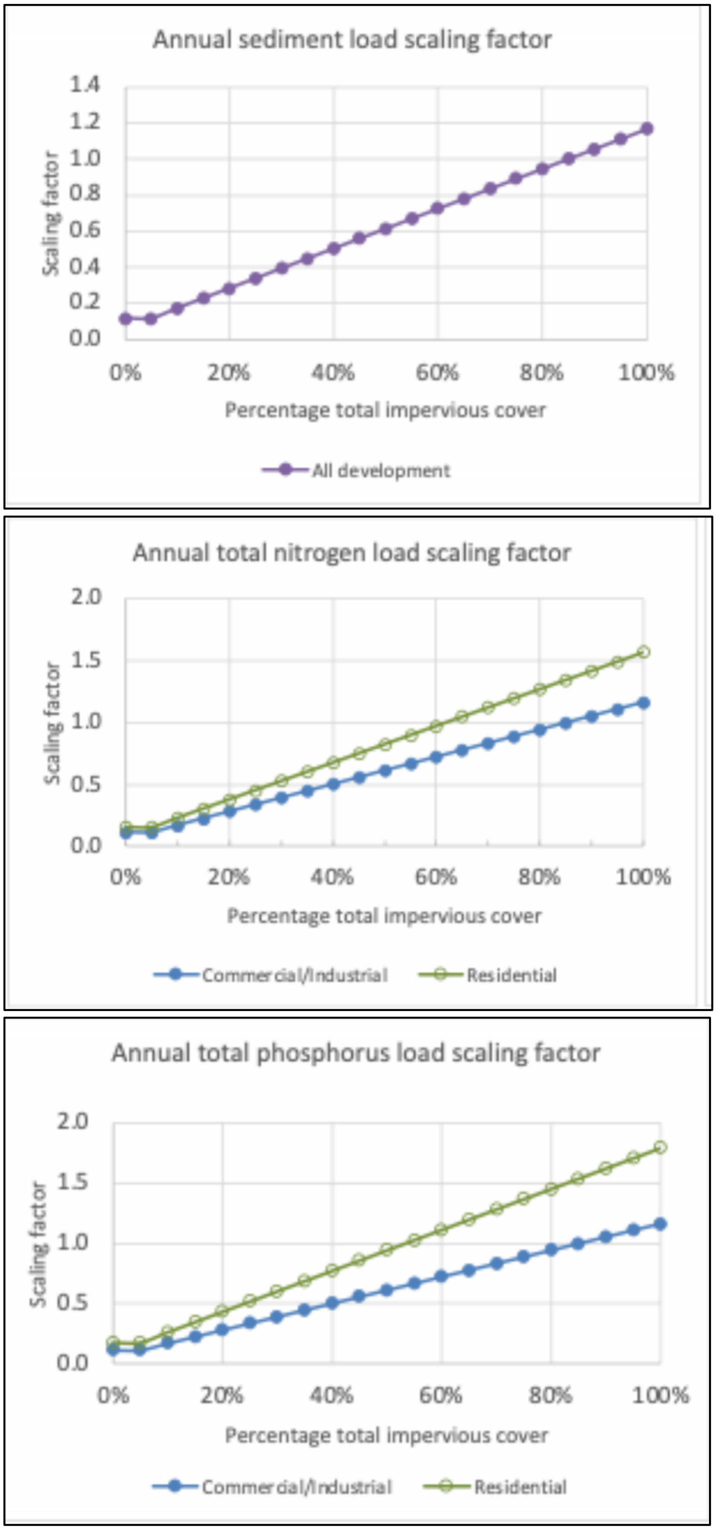


Figure A.4.1. *Example scaling factors that can be applied to adjust annual pollutant loads from new and redevelopments that differ from the baseline, 85% impervious commercial/industrial development (ECA) on which loads presented in Table A.4.1 are based.*

Examples of using the ECA and scaling factor methodology will be given in Memo 2.

A.4.3. Pollutant credit ratio

Nearly all offsite water quality programs require the application of what is known as a credit ratio (Section A.1). A credit ratio refers to the amount of pollutant reduction required at the offsite location relative to that which would otherwise be required onsite. The need for such a measure arises due to uncertainties in the amount of the pollutant(s) of concern that is actually transported from the offsite area to the waterbody of interest between the onsite and offsite locaitons (e.g., Tuttle Creek Lake or Wildcat Creek) versus what is retained elsewhere in the landscape. Pollutant delivery from a site is controlled by slope, soil type, and, especially, the hydraulic connectivity and distance to the receiving stream (e.g., Nejadhashemi et al., 2011); therefore, the load reductions reviewed in Section A.2 correspond to what is likely at the edge of the field or development site, but may not be representative of the sediment load ultimately delivered from a site to a TMDL waterbody. Additional uncertainty in the exact performance of the offsite BMP can also be accounted for in the credit ratio. A properly selected credit ratio balances both environmental and economic interests; the ratio should be high enough to promote environmental effectiveness to the satisfaction of regulatory interests while low enough to remain economically attractive to encourage participation by onsite properties. KDHE has specified a minimum credit ratio of 2:1 be used for alternative offsite compliance programs and this is the ratio that is in use for the program in Wichita. ***Thus, a minimum 2:1 pollutant credit ratio is specified for Manhattan's fee-in-lieu storwmater quality program.*** Other aspects of programmatic risks and uncertainty can also be accounted for and are described as part of the financial analysis presented in Memo 2.

A.4.4. Feasibility and Recommendations for Offsite BMPs

As evidenced in Appendix A.2, a variety of soil and water conservation practices could be implemented to address water quality concerns in both cropland and grazing systems. The pollutant credit fee to be paid by onsite property owners through the in-lieu fee program is based on the cost of the type(s) of BMPs anticipated to be the most commonly adopted by land managers to provide pollutant credits. Therefore, it is important to establish the feasibility of various agricultural BMP types to land managers in the offsite service area (Section A.4.1) along with the pollutant credits provided by the BMP and costs to incentivize adoption *and* maintenance of that BMP.

The following list provides general recommendations regarding offsite BMP selection. After discussion of general recommendations, we address feasibility considerations specific to the offsite service area under consideration (i.e., Figure A.3.1). General recommendations for Offsite BMP selection for the Manhattan Stormwater Fee in Lieu program include:

1. Provide flexibilility to the overall program by allowing pollutant credits to be provided through a suite of BMPs as opposed to only one.

2. Offsite BMPs should follow a defined geographic prioritization scheme to maximize the environmental effectiveness of the program (L. French, personal communication; CWP, 2012). As demonstrated through descriptions of the watersheds that comprise the proposed offsite service area in Section A.3, all areas can be considered priority as they drain to water bodies with documented impairments and active TMDLs. In the process for recruiting land managers to provide offsite pollutant credits, prioritization could be given to those managing lands in the riparian corridor with relatively high degree of hydrologic connectivity to impaired waterbodies and/or on lands with higher than average erosion rates.

3. Participation in and economic sustainability of the program is enhanced when the fee to secure pollutant credits through offsite BMPs is equal to or less than the cost to implement and maintain water quality BMPs on site.

4. When possible, offsite BMPs that provide a greater suite of ecosystem benefits (e.g., nutrient retention, soil health improvement, habitat quality, carbon sequestration) should be favored. For instance, in many cases, addition of cover crops is likely to provide a greater environmental good through enhanced nutrient retention, runoff regulation, and soil carbon accumulation than possible through structural practices such as terraces or streambank stabilization.

Offsite BMP feasibility considerations specific to the offsite service area under consideration for the City of Manhattan were guided by discussions with stakeholders currently working to advance adoption of water quality and soil health practices in these areas, including:

- Conservation District Office staff in Riley and Pottawattomie Counties
- County extension agents in Riley and Pottawattomie Counties
- K-State Watershed Extension Specialists working in Riley and Pottawattomie Counties
- Kansas Alliance for Wetlands and Streams (KAWS) staff working in Tuttle Creek and Middle Kansas River watersheds

These discussions underscored the following feasibility aspects of BMPs implemented cropland and grazing systems:

- No-till or reduced tillage systems are already in place in the majority of cropland systems in this area owing to the topography and soils. Thus, opportunities for additional no-till adoption are likely limited.

- Aging terrace and waterway systems pose water quality concerns in some cropland fields as breached and failing terraces can have very high rates of sediment delivery. Incentives to rehabilitate existing terraces could address this issue or provide a financial nudge to repair existing terrace-waterway systems rather than converting to tile outlet systems (which provide nominal water quality benefit).
- Interest in cover crops is high among land managers in this region. Recent signups for incentive payments through the Kansas Reservoir Protection Initiative (KRPI) in Pottawattomie County indicate land managers are willing to try cover crops with incentive payments. Anecdotally, there is evidence that land managers with land outside of current priority areas for incentive programs (e.g, Riley County above Tuttle Creek) are very interested in cover crop adoption but may not have done so yet due to lack of incentive payments in their location. Cover crops are typically implemented in associated with no-till in conventional cropland systems, though the small number of organic growers in the region use cover crops in conjunction with tillage (since no-till requires chemical herbicides that cannot be used in organic production systems).
- Cover crop adoption is often most feasibile to land managers who are able to graze them. Experience of the Tuttle Creek WRAPS coordinator indicates cover crop adoption often comes "through the backdoor" as part of broader efforts to move cattle out of riparian areas vi implementation of alternative water supplies and riparian exclusion fencing. Thus, considering water quality practices relevant to grazing lands (e.g., alternative water supply and fencing) is warranted.

These considerations as to the most feasible types of water quality BMPs in the proposed service area will be used to develop the set of BMPs that the in-lieu fee is most likely to incentivize and, accordingly, the magnitude of the fee.

A.4.5. Pollutant reduction credits ascribed to potential offsite BMPs

A combination of literature review and modeling was performed with a focus on total suspended solids and nutrient load potential and reductions. Sediment is recommended as the basis of pollutant credits given (1) it is a primary pollutant of concern in the watershed area draining to Tuttle Creek Reservoir, (2) it is associated with particulate nitrogen and phosphorus forms, such that if sediment load is reduced in watersheds with nutrient-related TMDLs (e.g., Wildcat Creek, the Big Blue and Kansas Rivers downstream of Tuttle) nutrient loads are also expected to decrease, and (3) there is generally a greater body of knowledge in the scientific literature regarding sediment load reductions achieved by agricultural BMPs relative to nitrogen and phosphorus, thus giving greater confidence in estimated load reductions. While sediment is recommended as the target pollutant for credit tracking in the initial stages of the program, the program framework is flexible in that other pollutants (e.g., total nitrogen or phosphorus) can be integrated as the program matures or as water quality priorities shift. Thus, the following review includes load reduction estimates for total nitrogen and phosphorus in addition to sediment.

Field-scale observations of sediment delivery from onsite (urban) or offsite (rural) cropland or grazing systems within Manhattan and the candidate offsite watersheds were not available. Therefore, a systematic method was applied to develop conservative estimates of baseline sediment loads (i.e., prior to BMP implementation) from these land uses in Manhattan and surrounding candidate watershed areas. Establishing the demand for offsite pollutant credits from development activities within the City as well as the supply of pollutant credits that can be provided by offsite BMPs is directly dependent upon baseline sediment loads; thus, it is critical to take due diligence in setting values for baseline sediment loads. The following sections describe the methods used to develop baseline sediment load estimates for offsite (i.e., grazing and cropland) areas in candidate offsite watersheds (Figure A.3.1), respectively.

Establishing offsite baseline: sediment yield models for cropland and grazing systems. Sediment erosion loads from cropland and grazing lands were estimated using the Revised Universal Soil Loss Equation (RUSLE) as described by Renard et al. (1997) and widely adopted by both federal agencies (USDA NRCS) and researchers (e.g., as reviewed by Michalek et al., 2021). The RUSLE erosion prediction method is a widely used empirical approach to estimate sediment losses at the field scale as a function of factors representing rainfall intensity (R), soil characteristics (K), the length and magnitude of field slopes (SL), cropping management practices such as tillage, crop, grass cover (C) and use of terraces and strip-cropping (P). Sediment delivery is then calculated as the product of these factors (Equation A.2):

$$Sediment\ delivery\ ((tons/acre)/year) = R * K * SL * C * P \quad (Equation\ A.2)$$

Literature values for each of these factors were selected to represent “low,” “moderate,” and “high” erosion potential for cropland and grazing lands in Riley County as summarized in Tables A.4.2 and A.4.3. Grazing and cropping systems are similarly distributed in the candidate watersheds identified for offsite BMP implementation, with cropping systems (namely corn-soybean rotations) common in areas with flatter topography, typically within river valleys, and grazing systems (grass that is grazed and/or hayed at least annually) common in uplands with higher slopes. Accordingly, the soil (K) and slope (SL) factors were selected to represent cropland and grazing systems were are characteristic of lowland and upland areas, respectively, in this area. The range values for each RUSLE factor were then fit to a normal distribution such that the “moderate” value was assumed to represent the average condition and the “low” and “high” values approximately 2 standard deviations below and above this mean, respectively. The probability of all other possible values for each factor was distributed approximately symmetrically around the mean, hence following the form of a normally distributed dataset.

Table A.4.2. RUSLE factor values assigned to cropland areas to characterize range in baseline sediment loss conditions in candidate offsite watershed areas. Values were used to define a distribution of representative values in which the “Moderate” value was assumed equal to the mean and the “low” and “high” values were approximately two standard deviations below and above the mean, respectively.

RUSLE factor	Low	Moderate	High	Data source(s)
Rainfall Erosivity Factor, **R;** Units 100s ft*ton-force/acre/yr	177	185	193	Renard et al., 1997; USEPA, n.d. https://lew.epa.gov
Soil Erodibility Factor, **K**: rate of soil loss per rainfall erosion index unit (units of ton*acre/(100s acre*ft-ton force*in); larger values indicate higher susceptibility of soil particles to detach and move by water.	0.3	0.4	0.5	Renard et al., 1997; K-factor given in USDA NRCS SSURGO soil dataset mapped in ArcGIS Living Atlas of the World

*Slope length and steepness factor, **SL***: accounts for influence of surface topography on erosion rates; increasing values indicate steeper and/or longer slope lengths with higher erosion potential; unitless	0.1	0.25	0.4	Renard et al., 1997; Range of slope of cropland areas determined from 30-m DEM-derived slope mapping from ArcGIS Living Atlas of the World
*Cover management factor, **C***: reflects effect of cropping and management practices on erosion rates; unitless	0.2	0.3	0.45	Renard et al., 1997; additional guidance for cropland under conventional tillage from USDA NRCS (nd)
*Support Practice Factor, **P***: ratio of soil loss with support practice to soil loss with upslope and downslope tillage; unitless	0.7	0.8	9.0	Renard et al., 1997; additional guidance for cropland with contour tillage from USDA NRCS (nd)

Table A.4.3. RUSLE factor values assigned to grazing areas to characterize range in potential values in candidate offsite watershed areas. Values were used to define a distribution of representative values in which the "Moderate" value was assumed equal to the mean and the "low" and "high" values were approximately two standard deviations below and above the mean, respectively.

RUSLE factor	Low	Moderate	High	Data source(s)
Rainfall Erosivity Factor, **R;** Units 100s ft*ton-force/acre/yr	177	185	193	Renard et al., 1997; USEPA, n.d. https://lew.epa.gov
Soil Erodibility Factor, **K**: rate of soil loss per rainfall erosion index unit (units of ton*acre/(100s acre*ft-ton force*in); larger values indicate higher susceptibility of soil particles to detach and move by water.	0.3	0.4	0.5	Renard et al., 1997; USDA NRCS SSURGO soils as mapped in ArcGIS Living Atlas of the World
*Slope length and steepness factor, **SL***: accounts for influence of surface topography on erosion rates; increasing values indicate steeper and/or longer slope lengths with higher erosion potential. Unitless	0.2	0.4	1.0	Renard et al., 1997; Range of slope of grazing areas determined from 30-m DEM-derived slope mapping from ArcGIS Living Atlas of the World
*Cover management factor, **C***: reflects effect of cropping and management practices on erosion rates; unitless	0.005	0.025	0.045	Renard et al., 1997; additional guidance for grazing land with range in grass canopy and soil cover USDA NRCS (n.d.) and Zobel et al. (2020)
*Support Practice Factor, **P***: ratio of soil loss with support practice to soil loss with upslope and downslope tillage; unitless	1	1	1	Renard et al., 1997; factor is not applicable to grazing land, which is assumed untilled

After defining normally-distributed value sets for each RUSLE erosion factor, a Monte-Carlo approach was followed to randomly select a value of *R, K, SL, C* and *P* from their respective distributions. These randomly selected factors were multiplied according to Equation A.1 to calculate an annual sediment delivery rate in tons/ac/yr. This process was repeated 100 times, resulting in a distribution of 100 values with a mean values representing combinations of "moderate" values of the RUSLE erosion factors (Figure A.1). Given uncertainty in actual factor values and how accurately they would represent offsite properties that may provide sediment credits to the fee-in-lieu program, a conservative estimate of the "baseline" sediment loading was defined as the lower 25th percentile of calculated sediment delivery (Figure A.4.2).

Corresponding baseline sediment loads were set as 2.4 tons/ac/year for cropland and 0.25 tons/ac/year in rangeland.

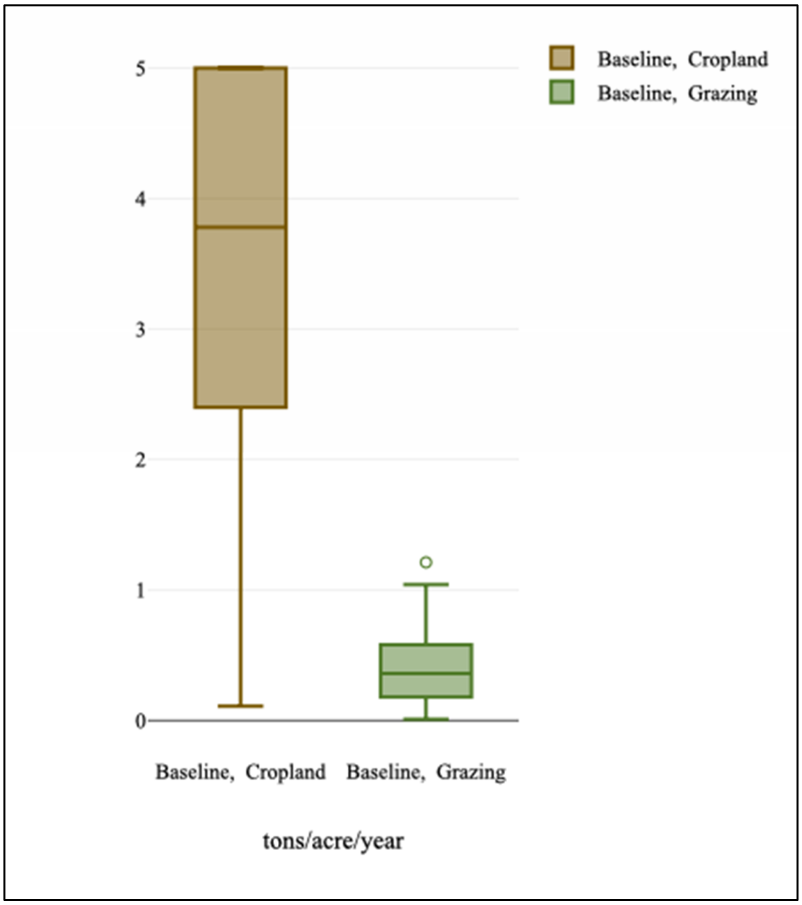


Figure A.4.2. *Box plot of calculated sediment delivery for cropland (left, brown box) and grazing lands (right, green box). The lower 25th percentile was selected as the "baseline" sediment load for crop and grazing land uses.*

Pollutant credits generated by offsite BMPs to meet ECA demand. A menu of candidate water quality BMPs appropriate for cropping and grazing systems in Riley County and the candidate watershed areas was developed in consultation with staff from local county extension office and non-profit conservation programs as discussed in Section A.4.4. Setting an appropriate price for the sediment credits that any of these practices provide is critical to setting an in-lieu fee that will sustain the program financially. This price is directly linked to costs to implement and maintain these BMPs as well as the extent to which they reduce field-scale sediment delivery below "baseline" loads (refer to Figure A.4.2). Thus, as with the approach for setting baseline sediment delivery, it was important to establish a systematic and conservative approach to estimate sediment retention. The following sections present the data and sources used to establish sediment reductions and associated sediment credits by offsite BMPs in cropland and grazing systems.

Sediment credits are defined as the reduction in annual sediment delivery achieved by a BMP, with units of tons sediment/year. Cropland BMPs are typically implemented and contracted on an area basis (e.g., per acre); therefore, we have used BMP area as a linear scaling factor, i.e., tons sediment/year/acre BMP. The following sections provide details on modeling and/or literature data that were used to set sediment credits generated by BMPs that are commonly implemented in cropping and grazing systems in northeast Kansas. The resulting set of sediment credits recommended for each BMP system is summarized in Table A.4.4.

Table A.4.4. *Summary of percentage sediment reduction and corresponding sediment credits generated relative to baseline cropland and grazing land conditions. Methods and data sources are presented in the following sections.*

BMP	% Reduction	Sediment credits generated (tons/ac/year)	ECA sediment load equivalents (ECAs) with minimum 2:1 sediment credit ratio applied
No-till adoption	60%	1.44	3.09
Cover crops with no/low tillage[a]	10% (incremental sediment reduction assuming no-till already in place)	0.24	0.52
Terrace-waterway rehabilitation with no/low tillage[a]	70% (8% attributed to terraces)	0.48	1.03
Vegetated buffer (filter strip) with no/low tillage[a]	50%[b]	0.96	2.06
Grazing riparian buffer exclusion	40%[b]	0.25	0.54

[a]While cover crops, terrace rehabilitation and vegetated buffers may be applied in conventionally or low/no-tillage systems, low/no tillage management is assumed as a most likely, more conservative condition. % reduction is applied as the marginal increase in sediment retention relative to no-till prior to applying to the baseline cropland sediment load (2.4 tons/ac/year).
[b]percent reduction applied to 2 acres of upland area per 1 acre of vegetated buffer assuming baseline grazing land sediment load (0.25 tons/ac/year) for the 2 acres

No-till adoption. The influence of tillage practices on field-scale sediment retention is commonly modeled using the RUSLE method by adjusting the cropping practice *C* factor (Equation A.1). Here, we used the RUSLE method in a Monte Carlo-based approach to calculate sediment load reductions that could be achieved through no-till conversion in the same way that baseline sediment loads were established. We then compared modeled sediment load reductions with values from the literature.

For the RUSLE sediment load calculation, the same distributions/sets of factor values for *R, K, SL,* and *P* were utilized as presented in Table A.4.2 for baseline conditions since these factors are assumed to remain the same regardless of tillage management. The *C* factor was adjusted to reflect adoption of no-till on crop rotations assumed most common for the region (corn-soybean and corn-wheat-soybean) following *C* factor values given in Renard et al. (1997). The resulting mean or "moderate" value was 0.1 with values of 0.06 and 0.14 representing two standard deviations below or above the mean of 0.1, respectively. The resulting quantile plots for 100 randomized calculations of the RUSLE sediment delivery with no-till adopted in place of conventional tillage are depicted in Figure A.4.3.

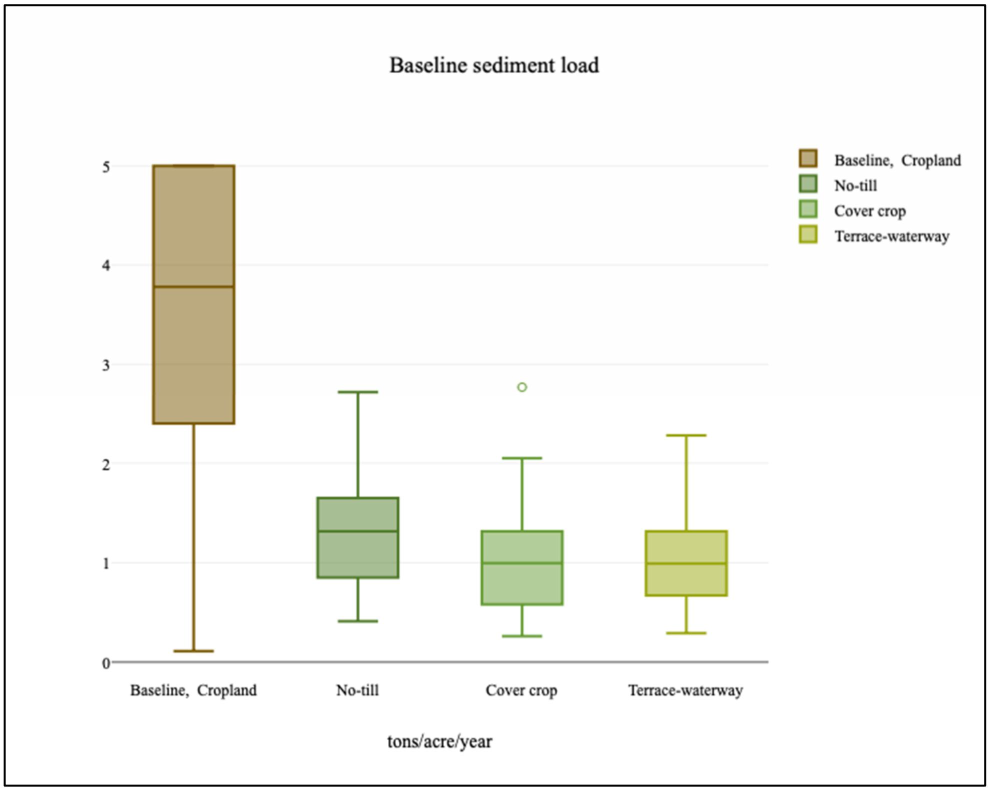


Figure A.4.3. *Box plot of calculated sediment delivery for cropland with no-till as a water quality BMP. The lower 25th percentile was selected as the sediment load upon which to base sediment credits ascribed to no-till adoption as an offsite BMP in the fee in lieu program.*

Calculated sediment loads and percent reduction relative to the baseline condition were compared to literature values to evaluate for comparability to field studies. Carver et al. (2022) measured sediment loads from field plots converted from conventional to no-tillage near Ashland Bottoms in Riley County, Kansas. They reported annual sediment loads ranging from 0.03 to 1.79 tons sediment/acre/year, the variability of which corresponded to interannual rainfall variation. Values of 0.5 to 0.6 tons/ac/year were observed during a "normal" rainfall year, which is comparable to the lower 25th percentile obtained through RUSLE models herein. Other studies have reported improvements in soil retention via no-till adoption as a % reduction. As reviewed by Faust et al. (2018), the median percentage reduction across 26 studies documenting sediment reductions following conversion to no-till was 65%, with an interquartile range (25th to 75th percentile) of 30% to 80%. Likewise, an expert panel tasked to assign nutrient and sediment load reductions for no-till adoption in the Chesapeake Bay region recommended percent reductions of 41% to 79% depending on soils and topography. Water quality modeling with the SWAT (Soil Water Assessment Tool) for watersheds across central and north central Kansas commonly yield a percent sediment load reduction of 60% for no-till adoption (A. Sheshukov, personal communication). RUSLE sediment yields obtained through the Monte Carlo approach utilized here indicated conversion to no-till would reduce median sediment loads by 65% relative to baseline conditions (up to 70% reduction for the 25th and 75th percentile loads). Thus, the RUSLE calculation approach taken here was deemed comparable to field studies and a percent reduction of 60% relative to baseline, conventional tillage conditions.

As noted in Table A.2.5, herbicide usage typically increases with no-till adoption as mechanical disturbance of the weed seed bed by tillage ceases and operators rely more fully on chemical control methods (Colbach & Cordeau, 2022; Margulies, 2012). Here, it is assumed that adoption of no-till as a water quality practice would be accompanied by herbicide application best management practices. As will be discussed in Memo 2, economic costs to adopt no-till as a water quality management system were calculated to include additional economic incentive payments to incentivize herbicide management.

Cover crop adoption. As with no-till, the influence of cover crops on field-scale sediment retention is commonly modeled using the RUSLE method by adjusting the cropping practice *C* factor (Equation A.1). Here, we use the RUSLE method in a Monte Carlo-based approach to calculate sediment load reductions that could be achieved through integrating cover crops with low/no tillage. This approach follows the same procedure used to determine sediment loads for baseline conditions and following adoption of no-till/low tillage. Modeled sediment load reductions were then compared to loads and relative load reductions values reported in the literature for comparison. It is assumed that a majority of cover crops implemented through the alternative compliance program will be implemented on acreage that is already in no-till or reduced tillage systems. **Thus, the RUSLE calculations were conducted to reflect the portion of sediment reduction that could be attributed to cover crops on top of sediment reductions already achieved by no-till. In other words, the sediment load reduction attributed to cover crops is incremental to that achieved by no-till.**

For the RUSLE sediment load calculation, the same distributions of values for the *R, K, SL,* and *P* factors were utilized as presented in Table A.1 for baseline and no-till conditions since these factors are assumed to remain the same regardless of cover crop management. The *C* factor was adjusted to reflect adoption of cover crops on no-till (or low tillage practices that minimize soil disturbance) following *C* factor values given in Renard et al. (1997). The resulting mean or "moderate" value was 0.08 with values of 0.04 and 0.12 representing two standard deviations below or above the mean of 0.08, respectively. Quantile plots for 100 randomized calculations of the RUSLE sediment delivery for cover crop integration with low/no-tillage are depicted in Figure A.4.3.

The distribution of sediment load estimates obtained through the RUSLE method had a median value of 0.9 tons sediment/ac/year with an interquartile range (25^{th} to 75^{th} percentiles) of 0.3 to 1.2 tons/ac/year. These estimates constituted a 70% to 75% reduction from baseline conditions compared to the baseline condition, which represents about 5% greater reduction than no-till alone. For comparison, Carver et al. (2021) measured runoff sediment loads from cover crop plots established in Ashland Bottoms, Riley County, over a 4-year period. Observed loads ranged from 0.01 to 0.45 tons/ac/year, with a median value of approximately 0.2 tons/ac/year. Given that our RUSLE-derived estimates are higher, our resulting estimates of the sediment credits provided by cover crops are likely conservative (under estimating). Other studies have reported water quality effects of cover crops as a percentage reduction. Christianson et al. (2020) and Faust et al. (2018) conducted independent literature reviews of cover crop field studies and reported median % reductions of 73% and 85%, respectively, relative to a baseline of conventional tillage. Interquartile ranges from these two reviews were overlapping and ranged from 30% to 85%. Thus, the percentage reduction of 70% to 75% obtained through RUSLE estimates is reasonable. A percentage reduction of 70% was selected as the sediment reduction achieved by cover crops with no-till. As stated above, it is assumed that a majority of cover crops implemented through this program will be implemented on fields that have already adopted no-till. This assumption follows the most recent agricultural census for Riley County, which reports that fewer than 10% of farms use full/intensive tillage practices (USDA, 2024). Thus, the credit rate ascribed to cover crops was 10%, which reflects the difference between the sediment reduction assumed for cover crop integration with no-till (70%) and the sediment reduction established for no-till only (60%).

Terrace-grass waterway rehabilitation. Terraces have been widely adopted in cropland systems with moderate to steep slopes over the last five decades. They are also used in relatively flat areas (< 5% slope) to control rill and sheet erosion. Adoption rates of this practice are high – for example, in the Clarks Creek watershed to the west of Manhattan, 90% of fields are estimated to have terrace-waterway systems (WRAPS, 2012). However, many of these systems are old and not all well-maintained. One of the strategies to increase sediment retention on such fields is to rehabilitate existing terrace-waterway systems to bring them up to standard practice guidelines (i.e., as described by USDA NRCS, 2011).

Reductions in sediment losses from fields with terrace-waterway systems can be estimated through adjustment of the P-factor in the RUSLE equation. P factors were adjusted from values presented for baseline conditions (0.7 ± 2 standard deviations; Table A.4.2) to reflect the presence of functional terrace-waterway systems (0.65 ± 2 standard deviations) based on ranges of values recommended by USDA-NRCS (n.d). The resulting range in P-factors (0.5 to 0.8) represents recommended ranges in terrace spacing and channel slope for field slopes of 2% to 4% (USDA NRCS, 2011), which represents the majority of surface slopes with cropland land uses across candidate watersheds in Riley County (while steeper slopes are typical of grazing lands). Considering overall water quality benefits, it would be more desirable to invest in sediment credits for terrace rehabilitation on no-till cropland than conventional tillage; therefore, the set of C factors input to the RUSLE equation for terraces corresponded to those specified for no-till. The probability distribution and quantile plots for 100 randomized calculations of the RUSLE sediment delivery for terrace-waterway rehabilitation with low/no-tillage are depicted in Figure A.4.3. This sediment load represents an additional 20% reduction from no-tillage, or a 70%-75% overall reduction relative to the baseline crop conditions.

Vegetated buffer establishment. Here, vegetated buffers are considered as an edge-of-field practice and thus, they are not part of the RUSLE framework. Thus, we used the literature to characterize sediment load reductions achieved by grass buffers from cropland systems. A recent review by Douglas-Mankin et al. (2021) summarized sediment and nutrient retention from published studies representing nearly 200 grass filter strips. The median percent reduction in sediment from their dataset was 85%, with an interquartile range (25^{th} to 75^{th} percentiles) of 68% to 95%. In an earlier review, Yuan et al. (2009) reported sediment trapping efficiencies in the same range, with a mean removal efficiency of 85% for buffers that were at least 20 ft (6 m) in width. While Yuan et al. (2009) found a significant influence of buffer width of sediment removal performance, Douglas-Mankin et al. (2021) found that sediment removal did not significantly differ between buffers that were 10 to 200 ft in width. The Chesapeake Bay nutrient reduction strategy relied on recommendations from an expert panel to set sediment and nutrient reductions achieved by grass and forest buffer restoration (CBP, 2022). The panel recommended a range from 40% to 52% depending on soils and topography. This range is lower than that reported from the literature by Yuan et al. (2009) or Douglas-Mankin et al. (2021), and thus represents a more conservative estimate. Here, we assume a value of 50% removal.

In addition to width, the ratio of upland area that is effectively treated by the vegetated buffer system to the area of the filter strip should also be considered. As with buffer width, Douglas-Mankin et al. (2021) did not observe a clear relationship between the percent sediment reduction and the ratio of the vegetated buffer area to the upslope treatment area. However, this ratio serves as a multiplier in determining sediment credits to assign to filter strips; thus, it is important to select a value that is reasonable. An expert panel tasked with assigning water quality performance credits to vegetated buffers as part of the Chesapeake Bay nutrient reduction strategy assumed a ratio of 2:1 upland area to filter strip area (CBP, 2022). This ratio is assumed herein as a starting point.

Riparian buffer exclusion (grazing). The primary BMP considered in grazing systems is riparian buffer exclusion in which livestock are physically excluded from riparian and stream buffer areas, typically by fencing these areas off. In most grazing systems, cattle and other livestock access streams and adjacent riparian areas for water and shade. However, this access results in streambank trampling, removal of herbaceous vegetation in buffer areas, and direct deposition of feces and urine in the stream. As a result, many riparian areas under livestock grazing are physically degraded and experience pulses of high fecal bacteria and nutrients. Fencing, which is typically physical but may be virtual, can be installed along the buffer on either side of the stream or waterway to prevent livestock from entering these areas. In addition to preventing direct deposition of pollutants in the water, this practice promotes the overall physical and biological integrity of the stream channel (see review by Krall and Roni, 2023) as well as riparian buffers and the water quality functions they provide. Thus, water quality benefits from this grazing BMP are two-fold. When adopting this practice, ranchers are often provided assistance to develop alternative water supplies and shade structures as livestock lose these benefits of riparian areas.

Many environmental incentive programs, such as offered through the Tuttle Creek Reservoir WRAPS program, also require ranchers to develop and implement prescribed grazing plans if they are not already doing so to ensure that grazing rotations, stocking rates, and other aspects of the grazing system promote healthy vegetation and soil conditions in upland areas. While prescribed grazing practices also contribute to sediment retention and avoided erosion, we focus only on sediment credits attributed to buffer exclusion practices. Accordingly, a literature review approach, similar to described for vegetated buffers in cropland systems was used to determine sediment retention benefits. Studies that addressed the combined effects of riparian buffer integrity and removal of livestock as a point source on water quality were prioritized.

Bartosz et al. (2020) directly address the question of water quality responses following riparian fencing in cattle grazing systems through a meta-analysis of existing literature. They found that reductions in sediment and fecal bacteria were more likely to be gained when buffers were greater than 16 ft to 33 ft (5 – 10 m) in width. In their review, the median percentage reduction in sediment following cattle exclusion from riparian areas was 61%, with an interquartile range of

30% to 78%. Bartosz et al.'s (2020) results were confirmed in a similar review by Krall and Roni (2023), who found that a majority (> 75%) of grazing exclusion studies in riparian areas found that TSS and/or turbidity decreased in response to cattle exclusion. A field monitoring study that was not included in either of these reviews was also identified and reviewed. In a 12-year, catchment-scale study in Arkansas, Pilon et al. (2017) demonstrated a striking difference in sediment loads between areas in which riparian buffers were fenced (59% less sediment than the baseline continuously grazed pasture without buffers) versus those that were not fenced (22% less than the baseline). Part of this difference in load can likely be attributed to enhanced runoff regulation in areas with riparian exclusion fencing, as Pilon et al. (2017) reported runoff volumes were 25% lower (significant at $p<0.1$) from these areas compared to grazed watersheds in which riparian buffers were either absent or were grazed. Annual percent reductions relative to baseline ranged from 52% to 86% over the 12-year study period for the riparian fencing treatment, with an interquartile range of 55% to 68%. Thus, the results of this study also fall in the range of Bartosz et al.'s analysis. Finally, a panel of experts engaged in the Chesapeake Bay nutrient reduction plan recommended a range of 40% to 54% for sediment reductions following livestock exclusion via riparian fencing (CBP, 2022). This recommendation falls between the 25th and 50th percentiles of the field studies presented by Pilon et al. (2017) and Bartosz et al. (2020), and is thus somewhat conservative relative to literature evidence. With this precedent, we adopt at percentage reduction of 40%, which corresponds to the lower end range provided by CBP (2022) and an approximate midpoint between the lower 25th percentiles reported by Bartosz et al. (2020; 30%) and Pilon et al. (2017; 55%).

As with cropland buffers, the upland area to which sediment reduction percentages should be applied is an important consideration. Here, we follow the same guidance established by the Chesapeake Bay nutrient reduction plan in which buffers in grazing systems are presumed to treat runoff from an area twice as large as the buffer; thus, we applied the percentage reduction from one acre of excluded riparian area to two upland acres with a "baseline" grazing system sediment loss rate of 0.25 tons/ac (Figure A.4.2); hence, this practice was credited with retaining 0.2 tons/ac/year.

A.4.6. Key watershed partners and potential roles in program implementation and administration

As noted in the offsite feasibility discussion in Section A.4.4, various watershed partners have been identified and engaged through this program planning process, including:

- Conservation District Office staff in Riley and Pottawattomie Counties
- County extension agents in Riley and Pottawattomie Counties
- K-State Watershed Extension Specialists working in Riley and Pottawattomie Counties
- Kansas Alliance for Wetlands and Streams (KAWS) staff working in Tuttle Creek and Middle Kansas River Watershed Restoration And Protection Strategy (WRAPS) programs

The role of these watershed partners is to serve as a conduit between the City and agricultural land managers willing to adopt new soil and water quality practices to provide pollutant credits (i.e., in terms of tons sediment per year) to offset pollutant generation by new and redevelopment sites that opt to participate in the program. In serving as this conduit, watershed partners can assume various forms of roles, including:

- *Education and dissemination*; sharing information about Manhatttan's program with land managers to raise awareness. This can be considered as a passive recruitment process.
- *Active recruitment*: identifying land managers in the proposed offsite service area who may be willing to adopt acceptable offsite water quality BMPs and recruiting them to the program
- *Technical assistance*: providing interested land managers with appropriate technical assistance needed to successfully implement the BMP
- *Coordinate contracts*: work with land manager to ensure they understand the terms of the contract to provide sediment credits to the Manhattan fee-in-lieu stormwater program (e.g., duration, practice maintenance requirements, incentive payment distribution, physical location and area to which the BMP is to be implemented.) In addition to obtaining signatures on the contract, watershed partners may also be in a position to collect any additional information needed to distribute payments to the land managers (e.g., address, W2).
- *Annual BMP checks*: As described in Section A.4.7, annual checks to ensure the BMPs through which contracted sediment credits are supplied are still in place are recommended. Watershed partners could provide these BMP maintenance checks and correspond with land managers if needed.

The following sections outline potential roles of the watershed stakeholders based on preliminary discussions. It is intended to outline potential roles but requires additional vetting and consideration by both these watershed partners and the City.

Both the Riley and Pottawatomie County Conservation Districts and affiliated staff and extension agents currently work in the areas identified in the offsite service area (Figure A.4.1). The Conservation District Offices serve as a local hub for both technical assistance and dissemination of available incentive programs. Discussion with Conservation District Staff indicate their willingness to disseminate information regarding BMP incentive payments available through Manhattan's alternative stormwater compliance program through their offices, social media, and electronic newsletters. Thus, they could play a "passive recruitment" role. Interested land managers would be able to signup through the conservation district office. A signup cap (e.g., acres of cover crops or vegetated buffers needed to attain desired quantity of sediment credits) would need to be provided to the district offices in advance. Conservation District staff would be in position to provide any needed technical assistance to implement BMPs and to coordinate contracts.

WRAPS programs in the Middle Kansas and Tuttle Creek Reservoir watersheds could also be leveraged to disseminate information and recruit land managers to provide pollutant credits for Manhattan's alternative stormater compliance program. Like County Conservation District Staff, WRAPS staff also work directly with landowners and/or managers of grazing and cropland systems to implement practices to improve water quality in their respective watersheds. Conversations with WRAPS staff indicate that they tend to take a more active recruiting strategy, seeking out land managers to implement new water quality and soil health measures. WRAPS staff time and BMP incentive payments to landmanagers are provided through EPA 319 funding, which requires BMP implementation in idenfitied priority areas of the watershed. Currently, the priority areas defined for both the Middle Kansas and Tuttle Creek Reservoir WRAPS program lay outside of the service area in Riley and Pottawatomie Counties identified for the offsite program (Figure A.3.1). However, KDHE recently submitted a proposal to the EPA to extend the Tuttle Creek WRAPS priority area to include Riley County along, for example, Fancy Creek. The timeline for EPA's review and approval of this proposal is unknown. Its approval would open the opportunity for the City to partner with WRAPS to actively recruit offsite BMP participants and provide technical assistance to implement those practices in Riley County above Tuttle Creek. WRAPS staff also incorporate regular (e.g., annual) follow-up with land managers to whom they are providing incentive payments to ensure contracted practices have been implemented as agreed upon and to provide additional technical assistance as needed to address any issues. Thus, the City could also partner with WRAPS staff to provide regular BMP checks to ensure the continuance of offsite pollutant reduction credits. We will explore potential to work directly with the Kansas Alliance for Wetlands and Streams (KAWS), the non-profit that supports staff positions within the Tuttle Creek WRAPS, as this may provide opportunity to work with Tuttle Creek WRAPS staff prior to EPA's approval of extending their priority area to Riley County.

A.4.7. Assessing program effectiveness

Establishing metrics through which to assess program effectiveness is important to demonstrate that sufficient pollutant credits are being generated offsite and that the program remains in compliance with the City's MS4 permit. Key metrics recommended to track the effectiveness of this program include:

- Estimated pollutant load reductions achieved through offsite pollutant credits relative to estimated onsite stormwater pollutant load generation
- In-lieu fees collected
- Expenditures (outgoing and committed) to offsite water quality credit providers (that is, to landowners/managers implementing BMPs)
- Characteristics of all implemented BMPs, including BMP type, location, and total area

While the financial aspects of the program are currently under development, it is likely that payments for pollutant credits will be administered as cost share to incentivize adoption of new water quality practices. The cost share incentive payment model is in keeping with the incentive payment model utilized by current WRAPS and USDA programs. For this reason, it is important to make the distinction between pollutant credits for ECA offsets and BMP acreage. Fee in-lieu payments made by onsite developers/property owners will be used to purchase an appropriate quantity of pollutant credits needed to offset onsite generation. The Equivalent Commercial Acre (ECA) as defined in Section A.4.2 can serve as the functional unit of this fee rather than the area of BMP implemented to meet the ECA demand (e.g., acres of cover crops). This distinction becomes particularly important in the likely situation that the program funds more than one type of BMP (e.g., cover crops *and* vegetated buffers) and, especially, for tracking ECA offsets through pollutant credits that were generated as result of incentive payments from the City separately from pollutant credits that result from a land manager's cost share.

Cost analyses and related determination of the fees to be assessed to developments that opt to participate in the alternative compliance program will be addressed in Memo 2. With this, considerations of how offsite BMP payments are dispersed, including through a cost-share incentive payment structure, will be discussed along with potential tracking methods.

HOLLY SPRINGS
Development Services

Stormwater Fee-In-Lieu Request Form

Submit this completed form as a draft with your Preliminary Stormwater Management Report.
An updated version of the form will need to be submitted with the final Stormwater Management Report.

CONTACT INFORMATION		
	Applicant/Financially Responsible Party	**Applicant Agent**
Firm Name:		
Contact:		
Street Address:		
City, State, Zip:		
Telephone:		
E-Mail:		

PROJECT INFORMATION	
Project Name:	
Project Number:	
Location:	
PIN Number(s):	
River Basin:	☐ Neuse ☐ Cape Fear

NUTRIENT REMOVAL INFORMATION Note: lbs. nitrogen/acre/year – Total Nitrogen		
☐ Total Site Area		Acres
☐ Existing Impervious Area		SF
☐ Proposed Impervious Area		SF
☐ Pre-Development Nitrogen Load		lbs/ac/yr
☐ Post Development Nitrogen Load		lbs/ac/yr
☐Nitrogen removed by SCM(s)		lbs/ac/yr
☐ Total Nitrogen = Post-Development Nitrogen Load minus Nitrogen removed by SCM(s)		lbs/ac/yr
☐ Fee Amount to be paid to TOHS Fee-In-Lieu (FIL) must be paid prior to issuance of Environmental Development Permit (EDP)	$	
☐ Supporting calculations for determining fee amount		
☐ Maintenance Agreement		

Neuse River Basin	Total Fee-In-Lieu = Number of lbs/ac/yr to be offset X Acres in Development X 30 years X $18.49/lb $ = lbs nitrogen/ac/yr X ac X 30 yrs X $18.49/lb
Cape Fear River Basin	Total Fee-In-Lieu = Number of lbs/ac/yr to be offset X Acres in Impervious Surface X 30 yrs X $14.00/lb. $ = lbs nitrogen/ac/yr X ac X 30 yrs X $14.00/lb

Figure A4.4. *Example of Fee in lieu calculation based on impervious surface area from City of Holly Springs, North Carolina* (available at https://www.hollyspringsnc.us/DocumentCenter/View/446/Stormwater-Fee-in-Lieu-Request-Form-16006?bidId=) Note that pre- and post-development nitrogen loads are provided by the applicant and are generally calculated by the designer using a state-approved nutrient load caluclation tool**.**

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