



CITY OF BOULDER

COMPREHENSIVE FLOOD AND STORMWATER MASTER PLAN

DRAFT

TECHNICAL MEMORANDUM #3

Stormwater Quality

DATE: February 18, 2022

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1 Introduction

In built urban environments, stormwater runoff must be actively managed to minimize adverse impacts to streams and drainageways. The city's Stormwater Quality Program works to preserve, protect, and enhance stream water quality and habitat by implementing a multi-faceted program to control pollutants at their source, attenuate and treat stormwater runoff from frequently occurring storm events, and implement stream health improvements. The major goals of the program include:

1. Reduce pollutant loading to streams. At a minimum, this includes complying with the city's Municipal Separate Storm Sewer System (MS4) permit certification and addressing Total Maximum Daily Load (TMDL) requirements such as those in place for *E. coli*. This also includes watershed improvement program measures that go beyond the minimum requirements of the MS4 permit.
2. Educate the public on the role they play in preventing and addressing pollution in Boulder.
3. Maintain and enhance urban waterbodies, including streams, riparian areas and wetlands. This includes collaborating across city teams and departments to implement a greenways¹ management program that improves and maintains the health of stream channels, wetlands and the riparian corridor, as well as provide enjoyable public spaces for the Boulder community.
4. Monitor and evaluate urban surface water quality. This goal recognizes the importance of evidence-based decision-making to guide assessment of water resource health, priorities and effectiveness of programs, capital improvements and maintenance approaches.
5. Adaptively manage the Stormwater Quality Program. Evolving regulatory requirements and environmental conditions require that the Stormwater Quality Program be managed in an adaptable and collaborative manner that engages in broader regional efforts and lessons learned related to stormwater quality.

¹ The City of Boulder Greenways system is comprised of a series of corridors along riparian areas including Boulder Creek and 14 of its tributaries, which provide an opportunity to integrate multiple objectives, including habitat protection, water quality enhancement, storm drainage and floodplain management, trails, recreation and cultural resources.



2 Policy Analysis

Many aspects of Boulder's Stormwater Quality Program are mandated by regulatory requirements under its MS4 Permit. The city also routinely looks for and takes opportunities to optimize the existing program and go beyond minimum permit requirements. Effective policies, therefore, are those that support meeting regulatory requirements; align with community needs and values; and incorporate flexibility to meet changing demands related to regulatory requirements, climate change, resiliency, and other considerations.

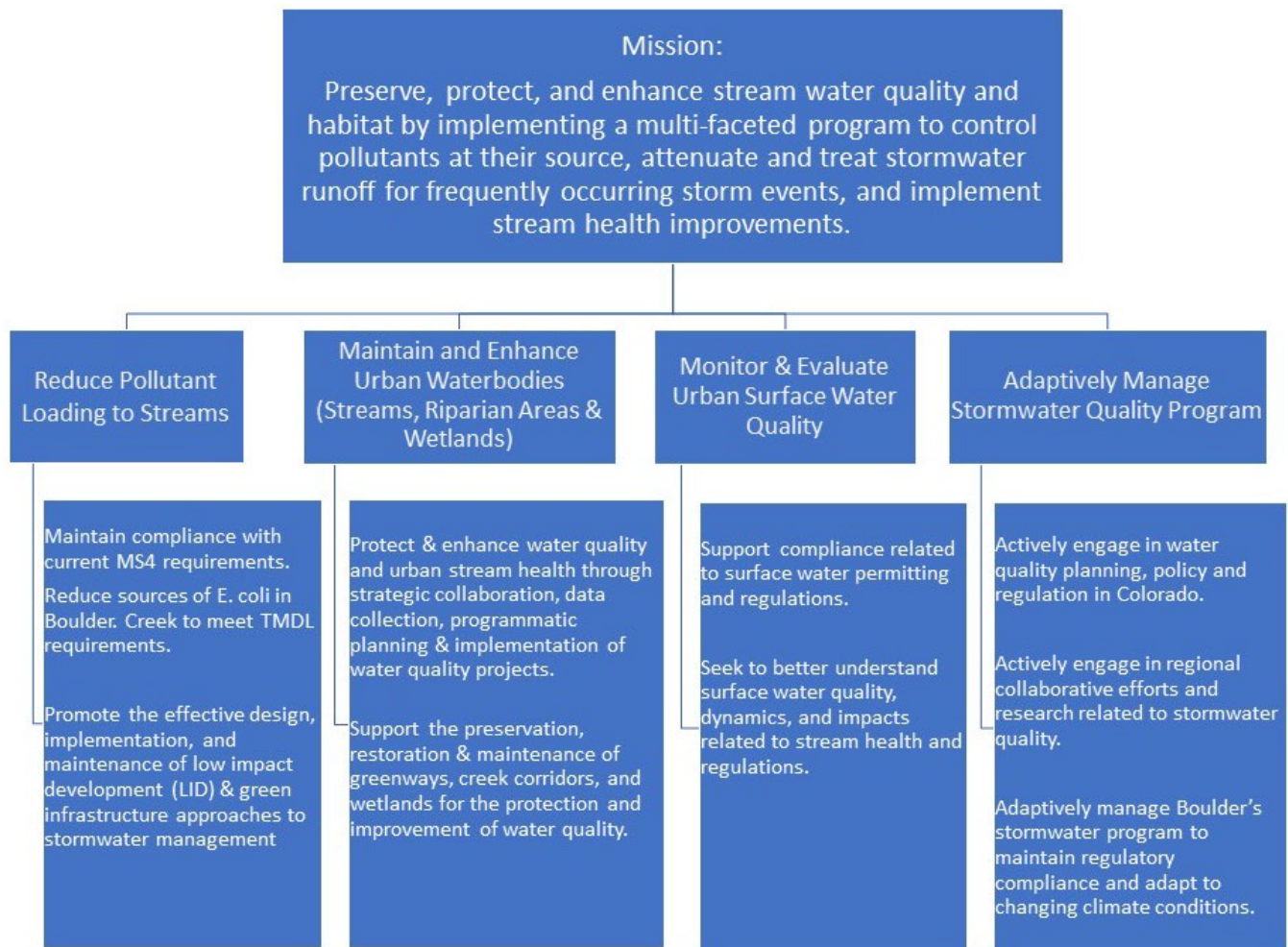
The city's Stormwater Quality Program was evaluated as part of Technical Memorandum 2 based on interviews with city staff and review of various program documents. Identified improvement actions from Technical Memorandum 2 are summarized below.

Identified Improvement Actions

- Incorporate Boulder Urban Stream Health program implementation into the Master Plan
- Track stream health function ratings
- Address management of the Greenways Program
- Evaluate success of the Green Infrastructure Strategic Plan
- Incorporate wetlands into water quality planning efforts
- Proactively preserve and restore wetlands

Policy and Program Goals

The mission of the city's Stormwater Quality Program is to preserve, protect, and enhance stream water quality and habitat by implementing a multi-faceted program to control pollutants at their source, attenuate and treat stormwater runoff for frequently occurring storm events, and implement stream health improvements. A series of working meetings among city staff, Community Working Group representatives, and the consultant team, resulted in the development of four overarching program goals, ten supporting goals (sub-goals) and associated objectives as summarized below. Recommendations to achieve each programmatic goal follow.



1. Reduce pollutant loading to streams.

GOAL: Maintain compliance with current MS4 permit requirements.

Objective: Meet or exceed regulatory requirements for minimum control measures.

Compliance requirements for the city's Stormwater Quality Program are clearly defined under its MS4 permit certification. Requirements include public involvement, public education and outreach, illicit discharge detection and elimination, construction-related erosion and sediment control, post-construction stormwater control measure (SCM) installation and maintenance, and municipal good housekeeping. The program is also clearly described in the program description document (PDD) and annual reports. It is recommended that the city continue with the current approach to MS4 compliance as the baseline for controlling stormwater-related polluted loading to streams. Opportunities to go above and beyond these minimum requirements are discussed further below.

In 2022-2023, Colorado's Standard Phase 2 stormwater MS4 permit is expected to undergo a substantive update that will likely include a series of more prescriptive "clear, specific and measurable" permit requirements. It is recommended that the city actively engage in stakeholder meetings and public comment on the draft permit to provide input to Colorado Department of Public Health and Environment (CDPHE) regarding expected benefits of potential new requirements so that efforts remain focused on actions that are most effective in reducing



pollutant loading to streams. The city should anticipate increased administrative and monitoring requirements under the forthcoming MS4 permit renewal.

GOAL: Reduce sources of *E. coli* contributions to Boulder Creek to meet TMDL requirements.

Objective: Work to identify potential *E. coli* sources and determine controllability.

Objective: Identify and implement strategies to reduce controllable sources of *E. coli* in stormwater runoff entering Boulder Creek.

Objective: Implement studies, policy initiatives and projects in coordination with other city initiatives that improve urban stream conditions and reduce *E.coli* loading to Boulder Creek.

Experience in Boulder and in other communities across the country has shown that there are no easy answers for *E. coli*. For more than 10 years, the city has actively engaged in *E. coli* source identification studies and implementation of appropriate abatement strategies to control *E. coli*. Based on the results of both outfall and instream monitoring, the city has begun developing and implementing sewershed management plans, as laid out in the [Boulder Creek *E.coli* TMDL Implementation Plan](#), to target storm drainage outfall networks with persistently elevated *E. coli* concentrations (GEI, 2019). Additionally, the city has used the latest scientific techniques such as using human DNA markers (e.g., *Bacteroides* HF183) to identify areas where possible sanitary sources could be contributing to elevated *E. coli*. The city should continue to use this science-based approach to prioritize areas for further investigation, focusing first on dry weather sources and highest risk sources such as sanitary sewage leakage from aging infrastructure or illicit discharges (WWE and Geosyntec, 2016). It is recommended that the city address potential water quality impacts from encampments through cooperation with the citywide encampment abatement approach, through expeditious clean-up of trash and debris along waterways and further analysis of other potential water quality impacts.

Based on outcomes of sewershed management plans and monitoring efforts, the city should work to address controllable sources of *E. coli* discharged from the city. Solutions for *E. coli* load reductions are likely to be iterative. In some cases, *E. coli* loading may be reduced, but it is unrealistic to remove all *E. coli* loading due to natural sources (e.g., birds, raccoons) present in the watershed. The city's program is relatively advanced in comparison to other communities in Colorado and on par with communities in other states that are faced with similar challenges to comply with *E. coli* TMDLs. While there are examples of *E. coli* load reduction strategies that can help to reduce *E. coli* loads, there are few, if any, examples of urban streams that have 100% compliance with *E. coli* TMDL targets. In summary, it is recommended that the city continue with source identification and load reduction strategies as dictated in the TMDL Implementation Plan. Completion of this systematic approach should trigger an update to the implementation plan that evaluates regulatory requirements, limited resources, and overall water quality improvement opportunities combined with realistic expectations of what may be achievable.

Currently, the city's MS4 permit has prescriptive *E. coli*-related requirements that apply to Boulder Creek between 13th St and the confluence with South Boulder Creek. The city should continue to evaluate *E. coli* impairments and sources on stream segments outside of the current TMDL reach, including Boulder Creek upstream of 13th St and South Boulder Creek between Highway 93 and the confluence with Boulder Creek, and should anticipate the need for outfall monitoring for these stream segments. If revised permits or new TMDLs are proposed, the city should actively participate in regulatory processes to share information and assist the state in developing meaningful requirements that recognize the advanced status of the program, and avoid duplicating prior monitoring and investigation efforts. The city should actively participate, where the opportunity allows, in research and state and



national policy discussions related to *E. coli* to stay current with various trends and know best how and when to engage.

GOAL: Promote the effective design, implementation, and maintenance of green infrastructure approaches to stormwater management.

Objective: Promote infiltration/green infrastructure as the preferred stormwater management strategy through policies for capital project and private development implementation.

Objective: Conduct education/training both internally and externally to improve SCM design and installation.

Objective: Enhance SCM maintenance and inspection program.

Objective: Evaluate options for implementation of SCMs for small sites <1 acre.



Given that most of the city's developable area has been developed, some of the most significant opportunities for improving stormwater quality are through incorporating SCMs into redevelopment sites, capital projects, and sites with less than one acre of disturbance, which is the threshold of applicability of MS4 permit requirements. Infiltration-based strategies that incorporate use of receiving pervious areas and filtration-based practices such as bioretention are particularly well suited to smaller sites. These practices are part of green infrastructure and low impact development (LID) approaches that provide stormwater quality benefits and often have other co-benefits for the community such as green space and cooling effects. As Front Range developers and contractors are still gaining experience with design and implementation of such approaches, the Utility has identified an ongoing need for training for

designers and installers so that these systems are properly designed and constructed. Additionally, existing, poorly maintained SCMs can become public nuisances and export pollutants. For this reason, focusing on enhanced maintenance and inspection of SCMs, with emphasis on educating owners on appropriate operation and maintenance practices is expected to reduce stormwater related pollutant loading, even without the construction of new control measures.

The city should explore the benefits of adopting SCM requirements for areas with less than one acre of disturbance in the city code. Currently, the city uses a review checklist approach to encourage use of LID on all development projects. However, formally defined upper and lower thresholds for which the city requires LID or green infrastructure could help to promote more widespread implementation of these approaches. Several other cities of comparable size to Boulder now require runoff reduction approaches to be implemented for development and redevelopment projects less than one acre. The thresholds of added impervious area triggering these requirements vary (e.g., 500 square feet to 5,000

| Colorado Municipality with Recently Updated Criteria | Threshold Triggering Stormwater Quality Control Measures* |
|---|--|
| Fort Collins | > 1,000 square feet impervious area increase |
| Denver** | Project > 0.5 acre |
| Commerce City | Projects with a cumulative disturbed area of > 5,000 square feet |
| Greenwood Village | > 500 sf impervious area increase |
| *Some exceptions apply. **Draft; proposed threshold. | |



square feet) and would warrant further analysis prior to adoption of revised thresholds in the city. Additionally, the city's Green Infrastructure Strategic Plan (Wood, 2019) provides a solid framework for the city to continue moving forward with green infrastructure implementation and should continue to be used as a guiding document for green infrastructure. A special emphasis for the incorporation of green infrastructure should be placed on projects constructed on city owned properties and as part of future capital improvements.

2. Maintain and Enhance Urban Waterbodies (Streams, Riparian Areas, and Wetlands)

GOAL: Protect and enhance water quality and urban stream health through strategic collaboration, data collection, programmatic planning, and implementation of water quality projects.

Objective: Identify and track the health and function of Boulder's urban streams.

Objective: Develop and implement stream management plans that identify in-stream and riparian maintenance protocols and restoration needs by stream reach.

Objective: Implement studies, policy initiatives, and construction projects in coordination with other city initiatives and work groups that improve urban stream conditions.

In 2021, the city initiated the Boulder Urban Stream Health program. This innovative program provides a substantial opportunity to improve water quality, enhance habitat for aquatic life and increase community enjoyment of local waterways throughout the city. For effective maintenance and enhancement of urban streams, an orderly, watershed-based approach is essential — basing stream improvement plans on scientific and engineering analysis so that needed stream improvements are prioritized and implemented in a manner that is sustainable and integrated in the overall stream network. The plan to first develop a scientific approach to assess and document stream conditions enables an objective and holistic evaluation of potential stream enhancement projects. Nationally, the water quality benefits of stream restoration are increasingly recognized as part of a sound water quality improvement strategy (Bledsoe et al., 2022); as such, it is recommended that the city continue to pursue this program. Implementation of the program should be an iterative and adaptive process. Regular, periodic evaluation of the program's benefits is recommended, with recognition that the benefits of stream management occur over a longer timeframe than other types of projects.

As a baseline understanding of urban stream health and as a framework for interdepartmental collaboration on stream enhancement projects is developed, it is recommended that the city continue to collaborate with external organizations, and in particular the Mile High Flood District to:

- formulate restoration plans for consistency with regional master planning efforts
- identify funding opportunities, and
- confirm eligibility for maintenance support

Through this collaboration, the city benefits from experience gained regionally with High-Functioning Low-Maintenance Stream (HFLMS) design approaches.



The urban stream health program should include a framework to track potential effects of climate change and actions that can minimize and/or respond to climate change in the context of stream health. Examples of potential impacts include water temperature increases, changes in spring runoff patterns and minimum instream flows, effects of drought on riparian vegetation, insect damage to riparian trees, changes in species composition (e.g., invasive species), increased frequency of extreme runoff events, and urban wildfire-related impacts to stream health. Given that



the city is located at the wildland-urban interface, planning for wildfire-related impacts includes coordination with Boulder County and other entities in the watershed related to risk in upstream watershed areas that may cause debris flows, water quality pollutants and increased flood risk. Efforts include previous risk evaluations (JW Associates, 2012) and Boulder County's [Wildfire Hazard Identification and Mitigation System](#).

GOAL: Support the preservation, restoration, and maintenance of greenways, creek corridors, and wetlands for the protection and improvement of water quality.

Objective: Support management of greenways and riparian zones to protect ecological function and community values.

Objective: Protect and preserve wetlands.

Currently, the city's organizational structure includes several separate programs related to urban stream health, greenway maintenance and wetland programs. These programs are important given the interrelated nature of instream conditions, riparian corridors, and wetlands and warrant further coordination. Additionally, as stream enhancements are planned and implemented, long-term sustainability requires maintenance such as weed control, trash pickup and removal of dangerous conditions (e.g., eroded banks, fallen trees) that can arise periodically from hydrologic events.

Protection of wetlands for their water quality and ecological benefits is a priority for multiple city departments. The city has adopted [stream, wetland and water body regulations](#) that are administered through the city's Planning and Development Services (P&DS) Department. The city's program goes above and beyond baseline federal regulations by protecting both the wetland area in addition to buffer zones around the wetland. The city also maintains open data layers in GIS identifying the location and boundaries of regulated wetlands known to exist within the city and provides public outreach to homeowners related to [minimizing impacts to wetlands](#). In support of the city's existing efforts related to the protection and preservation of wetlands, it is recommended that the Utility incorporate these efforts as part of the Boulder Urban Stream Health program and in conjunction with stormwater quality project planning initiatives.



3. Monitor and Evaluate Urban Surface Water Quality

GOAL: Support compliance related to surface water permitting and regulations.

Objective: Collect and evaluate water quality data in support of surface water permits and regulations.

The city maintains a long-term surface water monitoring program, including water chemistry, flow measurements and biological health assessments (benthic macroinvertebrates). This long-term monitoring program provides valuable information on current water quality and changes to water quality over time. This program also provides a scientific basis for assessment of stream impairments and informed input regarding future water quality regulations and permits. The monitoring program is one of several advanced long-term monitoring programs in the state, and should be continued, including regular data analysis and synthesis to determine long-term water quality trends. Additionally, integration of stormwater outfall special project monitoring with instream data is an important aspect of assessing the extent to which the MS4 program affects instream water quality, as well as providing an opportunity to link SCM performance with receiving water benefits.

The sampling program parameters, locations and frequencies should be periodically reviewed to ensure that the monitoring program is meeting applicable regulatory and science-based objectives. For example, if the city implements a runoff control or stream improvement project, then upstream-downstream (or before-after) monitoring related to such projects could be beneficial for quantifying the benefits of the projects.

GOAL: Seek to better understand surface water quality, dynamics, and impacts related to stream health and regulations.

Objective: Implement projects and studies to inform regulatory decisions related to city surface water permits.

The Stormwater Quality Program will benefit from special projects, studies and/or modeling efforts that evaluate the effectiveness of stormwater quality improvements. For example, the city can take advantage of regional and national SCM performance studies, but the program could benefit from watershed-scale modeling to evaluate the expected benefits of stormwater improvements implemented at scale in Boulder. The city should continue to promote the use of green infrastructure approaches on capital projects and should consider revisiting the water quality modeling efforts and recommended water quality installation projects listed in the stormwater master plan to incorporate infiltration-based approaches. Additionally, the city may want to monitor SCM installations to obtain locally based data on SCM performance, particularly if data gaps are identified for certain SCMs. Boulder has also participated in national nutrient-related modeling research with the Water Research Foundation; such projects can provide an opportunity to leverage directed research for the benefit of the city. Research projects, if implemented, should have well defined, hypothesis driven work plans and study objectives.





From time to time, the city has conducted special studies on pollutants of concern such as neonicotinoids. The Stormwater Quality Program should maintain flexibility for studies related to emerging contaminants (with PFAS as a recent example), microplastics, and other topics. The city has a history of partnering with the U.S. Geological Survey and other researcher entities on such topics.

4. Adaptively Manage Stormwater Quality Program

GOAL: Maintain a dynamic and compliant stormwater management program by engaging in state and regional regulatory and research efforts.

Objective: Actively engage in water quality planning, policy and regulation in Colorado.

Objective: Actively engage in regional collaborative efforts and research related to stormwater quality.

Objective: Adaptively manage Boulder's Stormwater Quality Program to maintain regulatory compliance and adapt to changing climate conditions.

The city should continue its active involvement in regional stakeholder groups including the Colorado Stormwater Council, the Mile High Flood District, and targeted stakeholder groups related to water quality and permit issues through the Colorado Department of Public Health and Environment and the Water Quality Forum. Early and active participation in these efforts helps to ensure that the city's interests are represented in regulatory actions. Additionally, regionally collaborative research can fill data gaps on topics such as the role of urban stormwater in nutrient loading to streams, design and performance of SCMs in space-constrained sites, evaluation of maximum extent practicable (MEP) performance standards for pollutants such as *E. coli*, and other topics. Such regionally collaborative efforts enable higher quality studies to be conducted through pooled resources and generally leverage regional knowledge to avoid duplication of efforts. For example, in Washington State MS4 permit requirements included SCM monitoring; however, a regionally coordinated approach resulted in each MS4 monitoring a specific type of SCM to fill specific data gaps, which minimized cost and provided a more complete data set.

Resilient infrastructure is a priority for the Flood and Storm Utility and should be incorporated into the Stormwater Quality Program to address the impacts of climate change. Analysis of factors that lead to resiliency and sustainability in SCMs is a topic of national research. Additional planning and evaluation are needed to develop tangible recommendations for SCM design, implementation and maintenance (e.g., vegetation selection, irrigation requirements). The city should continue to participate in regional efforts to better understand the effects of climate change on SCM maintenance.

It is recommended that the city evaluate its programs on a regular basis to identify changes needed to maintain regulatory compliance and to properly resource. For

Climate Change and SCMs

With warming temperatures, detention and water quality ponds are expected to experience heat stress on vegetation, as well as greater evaporation and evapotranspiration from ponds with permanent water surfaces or wetland ponds. Other potential system stresses include more frequent summer runoff events and reduced inter-event time. Consequently, increased maintenance may be required.

Temperature has many different effects on the kinetics of biological, chemical and physical processes in green infrastructure stormwater controls. Temperature increases are expected to modify the plant palette for many green infrastructure practices. Furthermore, runoff temperature moderation effects and non-stormwater urban heat island benefits are likely to become increasingly important if



example, the impact of climate change on urban streams is a rapidly evolving topic, which may require adjustment to policies, practices and research priorities related to stormwater quality.



3 Recommendations

The city's Stormwater Quality Program has a solid approach in place to comply with MS4 permit requirements. Additionally, the program has a clear vision to improve stormwater quality and stream health and provides a framework that allows flexibility to use evidence-based decision-making to refine specific actions.

It can take some time for the efficacy of stormwater quality measures within a watershed to be demonstrated. Non-point source treatment requires numerous SCMs across the watershed; and, given the diffuse and episodic nature of stormwater pollution, results are more likely to be observed as gradual improvements.

It is recommended that the Stormwater Quality Program conduct the following high priority actions to further enhance the program beyond regulatory compliance efforts:

- Increase the number of green infrastructure facilities on capital projects by participating and co-sponsoring projects to incorporate a runoff control component. This effort should aim for early integration of stormwater quality objectives into projects at the planning and conceptual stage and consider the co-benefits of green infrastructure approaches to develop multifunctional drainage solutions on city-led projects.
- Update the stormwater quality section of the Stormwater Master Plan to incorporate updated stormwater quality modeling techniques and identify priority stormwater quality treatment areas and projects using green infrastructure and infiltration-based approaches. Currently, the Stormwater Master Plan focuses on underground SCM water quality project locations which should not be considered the only possible approach.
- Develop and implement a systematic approach to evaluating and managing Boulder's urban streams and riparian areas through monitoring, management planning, and restoration/maintenance project completion. This effort should aim to integrate with flood management planning and consider the hydrology, hydraulics, vegetation, geomorphology, and community values functions of urban streams.
- Evaluate *E. coli* load reduction goals for Boulder Creek based on feasibility and cost-benefit of control measure implementation. This effort should be conducted following the completion of monitoring and evaluation efforts conducted as part of the TMDL Implementation Plan and consider the controllability of sources, risk to public health, and regulatory requirements.
- Encourage the community to take action in their neighborhoods and on their own properties to reduce stormwater runoff and mitigate pollutant sources through robust education and outreach programs.

Corresponding with the goals and objectives of this memo, the following stormwater quality policies and supporting actions are recommended for incorporation into the Master Plan:

- Maintain compliance with current MS4 permit requirements.
 - Meet or exceed regulatory requirements for minimum control measures.
- Reduce sources of *E. coli* contributions to Boulder Creek to meet TMDL requirements.



- Work to identify potential *E. coli* sources and determine controllability.
- Identify and implement strategies to reduce controllable sources of *E. coli* in stormwater runoff entering Boulder Creek.
- Implement studies, policy initiatives and projects in coordination with other city initiatives that improve urban stream conditions and reduce *E. coli* loading to Boulder Creek.
- Promote the effective design, implementation, and maintenance of green infrastructure approaches to stormwater management.
 - Promote infiltration/green infrastructure as the preferred stormwater management strategy through policies for capital project and private development implementation.
 - Conduct education/training both internally and externally to improve SCM design and installation.
 - Enhance SCM maintenance and inspection program.
 - Evaluate options and feasibility for implementation of SCMs for small sites <1 acre.
- Protect and enhance water quality and urban stream health through strategic collaboration, data collection, programmatic planning, and implementation of water quality projects.
 - Identify and track the health and function of Boulder's urban streams.
 - Develop and implement stream management plans that identify in-stream and riparian maintenance protocols and restoration needs by stream reach.
 - Implement studies, policy initiatives, and construction projects in coordination with other city initiatives and work groups that improve urban stream conditions.
- Support the preservation, restoration, and maintenance of greenways, creek corridors, and wetlands for the protection and improvement of water quality.
 - Support management of greenways and riparian zones to protect ecological function and community values.
 - Protect and preserve wetlands.
- Protect and enhance water quality and urban stream health through strategic collaboration, data collection, programmatic planning, and implementation of water quality projects.
 - Support management of greenways and riparian zones to protect ecological function and community values.
 - Protect and preserve wetlands.
- Support compliance related to **surface water** permitting and regulations.
 - Collect and evaluate water quality data in support of surface water permits and regulations.
- Seek to better understand surface water quality, dynamics, and impacts related to stream health and regulations.
 - Implement projects and studies to inform regulatory decisions related to city surface water permits.
- Maintain a dynamic and compliant stormwater management program by engaging in state and regional regulatory and research efforts.
 - Actively engage in water quality planning, policy and regulation in Colorado.



- Actively engage in regional collaborative efforts and research related to stormwater quality.
- Adaptively manage Boulder's Stormwater Quality Program to maintain regulatory compliance and adapt to changing climate conditions.



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