Colorado Municipal Separate Storm Sewer System Pollutant Removal Standard

Policy Analysis Exploration

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MS4, Permit, Stormwater Quality, Policy, Pollution Removal Standard, TSS, Total Suspended Solids, Standard Misalignment, Manufactured Treatment Devices

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Executive Summary

Polluted stormwater runoff is commonly transported in urban environments via municipal separate storm sewer systems (MS4) into nearby rivers and streams EPA developed Stormwater phase-1 and phase-2 regulations which established an MS4 program that manages and regulates urban stormwater impacts on water quality. The state of Colorado does not have a verification or certification system to test the effluent concentrations from manufactured treatment devices (MTD) to meet the current MS4 total suspended solids (TSS) pollutant removal permit standard of 30 milligrams per liter (mg/L). Most national and state testing entities who perform verification of the performance of MTDs report the pollutant removal standard of TSS as a percent removal rate which is a surrogate reporting measure. Having a difference between the MS4 permit pollutant removal standard and the national and state testing entities percent removal standard can create uncertainty regarding permit compliance for Colorado MS4 permitees when selecting MTDs. This research looks at the policy implications of various approaches to addressing the differences between Colorado MS4 TSS removal requirements and TSS percent removal used by state and national standards. This research conducted interviews of 8-subject matter experts and associated policy analysis matrices filled out by participants. Research indicated the need for Colorado to prescribe to a third-party verification system (like the STEPP program) and/or align with national standards of measurement in a percent removal rate with caveats that acknowledge TSS influent concentrations and particle size distribution while still protecting water quality standards for the citizens of Colorado.

Introduction and Background

Polluted stormwater runoff is commonly transported via municipal separate storm sewer systems (MS4) into nearby rivers and streams. Under the Clean Water Act Section 402 and associated amendments, the EPA developed the National Pollutant Discharge Elimination System (NPDES) which includes stormwater phase-1 and phase-2 regulations which established an MS4 program that manages and regulates stormwater impacts on water quality. The MS4 stormwater management program is intended to

improve the Nation's waterways by reducing the quantity of pollutants that stormwater carries into the storm sewer systems and ultimately into waterways such as creeks, streams, rivers and lakes in order to meet the goal of fishable and swimmable waters. phase-1 MS4 communities are urbanized areas with a population over 100,000 and phase-2 communities are urbanized areas with a population of 50,000 or have 10,000 people per square mile (US Environmental Protection Agency, 2022).

The state of Colorado does not have a verification or certification system to test the effluent concentrations to meet the current MS4 pollutant removal permit standard for TSS of 30 mg/L. Currently permittees must rely on manufacturer's confirmation or on third-party testing protocols (CDOT, 2021) from The State of Washington Department of Ecology Technology Assessment Protocol – Ecology better known as TAPE (Washington State Department of Ecology, 2023) or The New Jersey Department of Environmental Protection's Manufactured Treatment Device (MTD) verification list (New Jersey Department of Environmental Protection, 2023). These testing entities report the pollutant removal standard as the surrogate reporting measure, total suspended solids (TSS) with a percent removal rate. Additionally, both verification programs measure influent concentrations prior to treatment and the effluent concentrations of the tested devices. This departure from a percent removal to a more specific milligrams per liter metric makes Colorado the only MS4 permit in the nation to list standards of treatment in MS4 permits in this matter. This exploratory research project investigates the implications of different policy alternatives related to aligning Colorado TSS standards with national standards.

Currently MS4 practitioners must rely on data from manufacturers. This makes it difficult to determine the validity of the pollutant removal claims. Since these manufacturers convert the testing percent removal rate (from Washington and New Jersey) into a weigh per unit volume measure (mg/L) to determine compliance with Colorado's effluent limit of 30 mg/L, this creates ambiguities about whether or not permittees are meeting the pollutant removal standard in their MS4 permits (CDOT,

2021). Phase-2 MS4 communities did not receive the requirement to treat roadways within their MS4 permits until June of 2021. This is well after the phase-1 communities have been treating road-way projects greater than 1-acre of disturbance. This represents a significant increase in efforts to treat run-off from impervious roadway projects that typically have a constrained right-of-way or designated property to install water quality devices. MTDs are commonly used as an alternative in constrained sites. MTDs are typically small, do not incorporate flood control and commonly underground making them desirable for a constrained site.

There are many terms associated with devices or practices that treat stormwater run-off from impervious surfaces. These structures go by many different titles and names: post-construction control measures, post-construction best management practices, new development and/or redevelopment control measure, new development and/or redevelopment best management practices, permanent water quality features/control measures etc. These devices can be sub-categorized or grouped in many ways, for example: those that treat by filtration vs. those that treat by sedimentation; gray infrastructure vs. green infrastructure, built and designed on site or purchased and built in a factory; and structures that are on the surface vs. structures that are placed sub-surface. This exploratory research is focused on the process of looking at Manufactured Treatment Devices (MTDs) sometimes referred to as proprietary structures. Mile High Flood District (A Denver Metro area quasi-government agency), in its criteria manual update, describes MTDs to include many different types of proprietary devices that use various treatment processes and designs to remove targeted pollutants. For example, some MTDs are suitable for pretreatment and gross solids removal, whereas others incorporate advanced designs targeting specific metals, nutrients and other pollutants in stormwater runoff. Standardized testing protocols and third-party performance verification can be used to support selection of MTDs that meet treatment objectives for a site. (MHFD, 2022) Other agencies refer to these devices as “proprietary structures” (CDOT, 2021). The Colorado Department of Transportation (CDOT) defines them as typically

compact and installed underground, which makes them a preferred method for treatment in space-limited settings with low design flow rates. However, not all proprietary structures will meet the MS4 permit TSS design standard. (CDOT, 2021). See Appendix I, (from Fink & Anastasio, 2012) shows a typical hydrodynamic separator type of MTD design.

Proprietary MTDs, were proposed as potential cost-effective solutions for redevelopment and highway projects (Peterein & Buechter, 2011). The principal measure for comparing the performance between the selected BMPs is their discharge treatment, which was found to be a function of the influent concentrations for many constituents (Barrett, 2008). In addition, the MS4 pollutant removal standard uses the term “EMC” (event-mean-concentration), which is a statistical parameter used to represent the flow-proportional average concentration of a given parameter during a storm event. It is defined as the total constituent mass divided by the total runoff volume. When combined with flow measurement data, the EMC can be used to estimate the pollutant loading from a given storm. The primary aim of using the EMC approach to understanding BMP efficiency is to analyze wet weather flows at a site. In most circumstances, the EMC approach provides the most useful means to quantify the pollution level resulting from a runoff event (Urban Stormwater BMP Performance Monitoring, 2009).

In the absence of a complex, expensive, and time-consuming testing program of its own, CDOT has determined that proprietary structures meeting certain protocols established by other public agencies can be assumed to meet the MS4 permit TSS design standard. (CDOT, 2021) What is problematic is that these simple requirements do not reflect the reality of how BMPs perform in the field. (Kayhanian et al., 2009) Additionally, data interpreted from a verification system that utilizes a percent removal TSS verification must be interpreted and approved by Colorado agencies prior to installation. This is typically done by specifying the requirements of a treatment system and accepting the data from the manufacturer and painstakingly reviewing the data. Alternatively, a permittee may

rely on the Washington TAPE program or the New Jersey Department of Environmental Protection verification systems for acceptance and verification to a 50% or 80% TSS removal. The 80% TSS removal was written into MS4 draft permits in the past (CDPHE, 2011).

Clients:

The clients for this effort are the Water Quality Control Division (WQCD) of the Colorado Department of Public Health and Environment. This is the state department responsible for implementing the state designated NPDES program, including the permitting of MS4s, to prevent pollution, protect, restore, and enhance the quality of surface waters of the state of Colorado (CDPHE, 2023). The clients at the WQCD Permits Section are Unit Manager, Randi Johnson-Hufford and Environmental Protection Specialist, Mary Welch.

The secondary client for this research is the Colorado Stormwater Council. The Council is an organization of local MS4s, comprised of cities, counties, and special districts throughout the state of Colorado with a mission to effectively protect and improve stormwater quality through collaboration, resource sharing, local partnerships and the focused efforts of special committees (CSC, 2023). Specifically, the post-construction committee was selected to review results and ensure that a balance of differing opinions is heard. The Council provides a good network of communities and the associated technocrats (subject matter expert (SMEs) to select from for this study. The Post-Construction Committee was formed to address permanent control measures and their effectiveness and compliance with MS4 permits. This type of policy research is high on the priority list of concerns for the committee. The Council and WQCD have been enthusiastic with their support of this research study. The proposal approaching these organizations and guiding document can be found in appendix-A.

Colorado has a unique 30mg/L TSS standard among MS4 permits across the nation. This research will explore the policy solutions and alternatives. This research poses the question, what are

the policy implications of various approaches to addressing the differences between the Colorado MS4 TSS removal requirements of 30 mg/L and nationally used 80 percent TSS removal verification programs to aid in alleviating compliance concerns for MS4 permittees? To answer this question, this paper reviews the relevant literature before describing the methodology for this research. Then, it presents the results of the analysis before discussing these results and providing recommendations.

Literature Review

Most research that comes from the world of manufactured treatment devices for stormwater treatment (post construction control measures) comes from government bodies such as the Environmental Protection Agency or Government sponsored/supported organizations. Other resources come from quasi-governmental organizations i.e., Mile High Flood District. Existing stormwater standards do not provide clear direction regarding how to objectively and quantitatively evaluate the required (best management practices) BMP treatment effectiveness (Jones et al., 2011). To be precise, standards typically lack TSS influent concentration and particle size determination. Even in Colorado MS4 permits, there is not a methodology for determining boundaries for influent concentration or particle size in relation to determining the 30 mg/L TSS effluent concentrations. This problem is not unique to Colorado, but Colorado is the only state to require a standard milligrams per liter standard wastewater treatment numeric limit within an MS4 permit. The debate on which standard continues, particularly among manufacturers.

Engineering Arguments

Manufactured treatment devices (MTDs) are increasingly installed to treat pollutants from stormwater in urban areas, but few peer-reviewed studies have assessed their field-scale performance. (Smolek, et al., 2018)

Milligrams per Liter Argument

The researcher will start with the argument against a percent removal standard. This standard ignores what the influent concentration of pollutants (industry uses TSS as the analyte) if a 10 mg/L TSS influent is treated in an MTD, it is expected the MTD will remove 80% of the TSS as opposed to the structure removing 80 mg/L of TSS. This leaves an effluent concentration of 20 mg/L. This would be a standard well below the Pollutant removal standard of 30 mg/L required in Colorado MS4 permits. Appendix K demonstrates the differences in the sample equations. In addition, it is below wastewater treatment standards of 30 mg/L (CDPHE, 2008). This is speculated to be the source of the 30 mg/L permit standard in Colorado. CDPHE simply used a well-established wastewater system standard and applied it to the pollutant removal standard in the MS4 permitting system. Another speculated yet unconfirmed source is a study conducted for section T-11 of the Mile High Flood Districts, Urban Storm Drainage Criteria Manual Volume-3 that looked at the International BMP database and determined that the 30 mg/L effluent limit level of treatment is comparable to the long-term effluent median concentrations from the International Stormwater BMP Database for surface-based BMPs (MHFD, 2012). The assumption here is that this standard will treat as well as capture the surface water quality with a volume-based permanent control measure. MS4 permits are a practice-based permit system. The assumption is if you are performing and installing control measures per their intended design you will meet water quality standards. Most Colorado MS4s have no requirements to ensure the effluent quality of installed permanent control measures. While a memo from the EPA slightly refutes this standard practice by recommending that NPDES regulated municipal stormwater discharges effluent limits be expressed as BMPs rather than numeric effluent limits. The memo provides guidance to use an iterative process to improve stormwater management over time (EPA, 2014). This is not considered to universally held doctrine within the stormwater quality community and only an interpretation that we have moved beyond practice-based control measures for NPDES compliance. Early investigation into the International BMP database found that percent removal of pollutants was a highly problematic method

for assessing performance and has resulted in some significant errors in BMP performance reporting (Strecker et al., 2003). It appears using a volume to weight based (mg/L) or concentration metric would be the sensible engineering answer. In most (if not all) cases one would find that BMPs tend to work better during small storms, especially BMPs that rely on volume storage and settling (otherwise known as sedimentation).

Percent Removal Argument

It stands to reason that an additional weight should be added to the data set to provide an adjustment which weights the data to be more representative of what will statistically occur over a period of time vs. what just happened during the sampling period (Kayhanian, Roseen, Lenhart & Williams, 2009). There is little documented evidence regarding the decision to use the volume to weight based (mg/L) standard in Colorado and be the first in the nation to so for MS4 permits. Investigation and interview questions are proposed to find the source of this reasoning. Programs like TAPE and NJDEP still utilize the 80% TSS benchmark for verification of MTDs. Manufacturers and regulators have become accustomed to these standards. Looking at both a volume to weight based (mg/L) and percent removal side by side may lead to the conclusion that, to understand the operation of the BMP (or control measure), one must look at both load and concentration to make a decision about performance (Kayhanian et al., 2009). This statement succinctly describes water quality impacts but has this philosophy led the manufacturing and regulatory apparatus to an arms race to finer and finer controls only to add to confusion of the effective use of MTDs. The argument for a percent removal is simplicity and uniformity of this system. The influent concentration is removed thus it is solely focused on the effluent concentration. While this ignores some of the nuances of a mg/L verification system, the percent removal TSS verification is simple to implement and understand and is accepted by most other states and verification systems.

International BMP Database

BMP Database project, which began in 1996 with the long-term goal of gathering transferable technical design and performance information to improve BMP selection and design so that local stormwater problems can be effectively addressed. In 2004, the project transitioned from a US-EPA funded grant project to a more broadly supported coalition of partners including the Water Environment Research Foundation (WERF), ASCE Environmental and Water Resources Institute (EWRI), Federal Highway Administration (FHWA) and the American Public Works Association (APWA) (Urban Stormwater BMP Performance Monitoring, 2009). These entities continue to provide long-term support of the project. The cornerstones of the project are the BMP monitoring and reporting protocols and the BMP database itself, which were developed based on the input and intensive review of many experts for the purpose of developing standardized reporting parameters necessary for more accurate BMP performance analysis. The database encompasses a broad range of parameters including test site location, watershed characteristics, climate data, BMP design and layout characteristics, monitoring instrumentation, and monitoring data for precipitation, flow and water quality (Urban Stormwater BMP Performance Monitoring, 2009). The differences in monitoring strategies and data evaluation alone contribute significantly to the wide ranges of BMP "efficiency" (typically percentage removal) that has been reported in the literature to date (Strecker et al., 2003). The BMP database manual that is used for management of the BMP database focuses primarily on the collection, reporting, and analysis of water quantity and quality measurements at the heart of quantitative BMP efficiency projects. It does not address a number of details including: sediment sampling methods and techniques, biological assessment, monitoring of receiving waters, monitoring of groundwater, streambank erosion, channel instability, channel morphology, or other activities that may be more useful for measuring and monitoring water quality for assessing BMP efficiency (Urban Stormwater BMP Performance Monitoring, 2009). The BMP database, while a treasure of quantitative research possibilities, does not

investigate the feasibility of installation, costs and contextual data overload demonstrated in the International BMP database and guidance documents. BMP monitoring is expensive and care should be taken to ensure that the study design will enable the researcher to draw statistically significant conclusions or meet other objectives such as permit requirements (Urban Stormwater BMP Performance Monitoring, 2009). Bridging the gap between a post-installed field verification and a pre-installed lab-based verification is a current struggle in the stormwater quality field.

A solution to approve products before they are installed has been used by the NJDEP to verify and test products in a lab setting. There is an effort to codify this lab-based verification of performance in an American Standards and Testing Methods (ASTM) This test method concerns measurement of selected hydraulic characteristics of hydrodynamic separators and underground settling devices critical to their function as stormwater treatment devices. To be clear, it is better to field verify a product than to lab test the product but there is confounding information regarding background data that it is hard to determine what an MS4 permittee should choose when looking for an MTD. To resolve potential interpretation issues regarding suspended sediment, it is recommended that both TSS (for comparison to existing data sets) and suspended sediment concentration be measured. One of the reasons that this issue has received much attention is that various state and local regulations and technology verification protocols have chosen to use TSS as a performance measure, so a clear understanding of the TSS method and procedure used is important to performance evaluations (Urban Stormwater BMP Performance Monitoring, 2009). Appendix J depicts solids size classification. A particular issue with verification systems and often omitted from specifications for MTDs is particle size distribution. It is easy to remove large particle and trash but as particle size decreases it become harder and more expensive to remove dissolved pollutants and clay sized particles as seen in appendix J. A successful and economically viable water quality sampling program requires careful forethought regarding the types of equipment for sample collection and types of constituents to be analyzed. To yield usable data,

procedures for proper sample collection and analysis must be clearly defined upfront in a written monitoring plan and carefully followed in the field. A successful water quality monitoring program is also dependent on strong experimental design that will yield data sets enabling statistically significant conclusions to be drawn regarding BMP performance (Urban Stormwater BMP Performance Monitoring, 2009).

Qualitative Research in TSS Studies

There is surprisingly little qualitative research on TSS policy and existing data is mostly quantitative data centric. Most journals that provide quantitative data come from the American Society of Civil Engineers. The few papers that dive into policy research discuss the over-use of quantitative data within the engineering sector. Observations at an international engineering education research conference uncovered a strong preference for quantitative methods and their associated evaluation criteria, likely due to most participants technical training (Borrego et al., 2009). While qualitative data seems to be looked down or frowned upon qualitative research is rigorous and involves its own set of data collection and analysis methods that ensure the trustworthiness of the findings (Borrego et al., 2009). Additionally, engineering educators who have been trained primarily within the quantitative tradition may not be familiar with some of the norms of qualitative research (Borrego et al., 2009). Quantitative research places the burden of demonstrating generalizability on the researcher, while qualitative research places the burden of identifying appropriate contexts for transferability on the reader. Just as rigorous statistical analysis is essential in quantitative research to ensure reliability and generalizability of the results, so too is rich description of the context and experiences of the participants essential in qualitative research to ensure trustworthiness of the findings and transfer to other contexts (Borrego, et al., 2009). Table 1. presents the key criteria and juxtaposition of quantitative vs. qualitative research demonstrating a lack of qualitative research in this very engineering centric subject. It also helps illuminate why there is little qualitative policy research on the subject.

Table 1

Quantitative Research Criteria	Qualitative Research Criteria
Validity: project and instruments measure what is intended to be measured	Credibility: establishing that the results are credible or believable
Generalizability: results are applicable to other settings, achieved through representative sampling	Transferability: applicability of research findings to other settings, achieved through thick description
Reliability: findings are replicable or repeatable	Dependability: researchers account for the ever-changing context within which the research occurs
Objectivity: researcher limits bias and interaction with participants	Reflexivity: researchers examine their own biases and make them known

There appears to be a trend towards the use of quantitative methods, and even within the quantitative area only certain approaches are deemed to be worthwhile (Borrego et al., 2009).

Other limited resources on qualitative studies as it relates to MS4 permitting have been focused on innovation and acceptance of technology. To improve technologies that address pressing issues in stormwater treatment, it is critical to coordinate innovations with the regulators and the practitioners that approve, design and implement stormwater BMPs (Herzog et al., 2019). The International Stormwater BMP Database, the Washington Department of Ecology, and the New Jersey Corporation for Advanced Technology were all cited as influential regulatory gatekeepers, along with regional and state water quality regulators. These results align with literature, showing that in most countries, local stormwater agencies simply adopt regional or national stormwater guidelines (Herzog et al., 2019). While the Herzog et al., study focused on in-stream BMP technologies in California and Colorado the premise holds true for manufactured treatment devices in general. This study did not look at TSS policy analysis nor was it closely looking at performance of MTDs.

The principal measure for comparing the performance between the selected BMPs is their discharge quality, which was found to be a function of the influent concentrations for many constituents (Jones et al., 2011). To solve current urban water infrastructure challenges, technology-focused researchers need to recognize the intertwined nature of technologies and institutions and the social systems that control change (Kiparsky et al., 2013). This represents a chicken-and-egg conundrum, because a BMP cannot be constructed in the field without prior performance data, but field performance data cannot be collected without a pilot field site. Designing, approving, and constructing a new BMP can take several years. Subsequent performance monitoring for multiple contaminants across different seasons requires significant investments of time and funds, which can be substantial hurdles to innovation (Herzog et al., 2019).

Exhaustive searches of multiple databases, including Google Scholar, ProQuest, WestLaw and multiple databases concerning water policies and laws turned up surprisingly little in the way of qualitative research as it relates to stormwater quality or TSS removal. While there is plenty of engineering and scientific quantitative information on these subjects, little is known about how these policies and how the data are affecting the water quality community. Most efforts to look at this have started only in the last few years and have been led by World Environmental and Water Resources Congress (EWRI) and National Municipal Stormwater Alliance (NMSA). NMSA has developed and disseminated surveys looking at “the state of the U.S. stormwater sector” since 2018 (National Municipal Stormwater Alliance, 2023). This type of survey led to the development of the Stormwater Testing and Evaluation for Products and Practices (STEPP) program and the ASTM E64 committee. It should also be noted that information dissemination among stormwater experts is primarily performed at large conferences and documented in conference proceedings. This is considered peer reviewed material by the American Society of Civil Engineers (ASCE) and is generally logged with the ASCE journal database. Most quantitative data can be found here. The body of knowledge on the subject is vast and

complex. This appears to be what has led to consumer-overload (McShane et al., 2017). So many choices exist that lack unification of a standard. Even in the BMP database guidance they point out three separate testing measures for obtaining TSS results from the field after a control measure has been installed. This study is an exploratory qualitative study aimed at filling the policy research gap in proprietary devices or MTDs and the selection of those devices before installing them to ensure compliance with the Clean Water Act.

How the Literature Informs this Research

Review of scholarly, legal documents, engineering documents, permits, committee meetings, manuals and conference proceedings has produced a literature review that points to 3 issues:

- There are surprisingly little qualitative studies within this heavily influenced field of engineering and science of TSS research with almost no academic policy research.
- There is a willingness and desire to conduct this research in Colorado.
- While there is still debate in the engineering field over the use of a weight to volume (30 mg/L) TSS based standard vs. a percent removal TSS based standard, Colorado is unique in the nation with this standard written into MS4 permits.

These reasons support the exploration of this issue for the state of Colorado and MS4 permitees that support good water quality and fiscal responsibility for the citizens of Colorado.

Methodology

This research addressed the question, what are the policy implications of various approaches to addressing the differences between Colorado MS4 TSS removal requirements and national standards? The purpose of this policy question is to explore ideas through a policy analysis matrix and supplement this information with interviews from a group of elite technocrats (subject matter experts) who have extensive background in MS4 policy or in the implementation and testing of MTDs.

Sampling

The researcher sought to achieve maximal variation in the sample, which entailed integrating only a small number of cases, but those with as many differences as possible; the approach allows research to capture a range of differing perspectives in the field (Flick, 2007).

Sample size was determined by careful selection between the clients of CDPHE and utilizing the network of the Colorado Stormwater Council. The policy analysis matrix was established as the primary source of data. The matrix required extensive thought and curation through meetings with CDPHE to establish the policy alternatives to explore possible policy solutions for Colorado MS4 permittees. Interviews were designed to supplement the policy analysis matrix by exploring the knowledge base of the selected technocrats and dive deeper into the policy question. The interviews were structured with questions approved by CDPHE prior to dissemination (appendix-A) but follow up questions and key thought questions were asked during the interview (appendix-F). The researcher reserved the right to present follow-up questions, clarifying questions and to dig into comments and themes deeper. This required the researcher to know the subject of policy research, TSS testing standards (both across the nation and within Colorado) and interview techniques. To be an effective interviewer, the subject must be researched and understood and there must be room to explore with follow up questions. This is the nature of a qualitative interview that is exploratory in its nature. Per, Svend/ Kvale “The qualitative stance involves focusing on the cultural, everyday and situated aspects of human thinking, learning, knowing, acting and ways of understanding ourselves as persons”. This interview process was primarily a listening exercise. Questions were also developed to explore issues that were unique to the organization that each SME represented. The basis upon selection of the eight interviewees were as follows:

- Experts within the Colorado Stormwater Council on Post-Construction Control Measures
- Geographical representation i.e., Western slope vs. Front Range

- Large MS4 populations over 100,000 people (phase-1) vs. Medium MS4 populations over 50,000 people (phase-2)
- Experts in MTDs and national policies
- County vs. City MS4 implementation

See Appendix B, for the list of subject matter experts and appendix-C for biographies of each subject matter expert. The intended comparison: the dimensions and levels on which the researcher intended to draw comparisons (Flick, 2007) across the state of Colorado and determine qualitatively a preferred policy for the TSS pollutant removal standard common among Colorado MS4 permits. In protecting against confirmation bias, the tendency to focus on evidence that confirms our expectations or favored explanation and can lead us to false conclusions (Nickerson, 1998). The researcher utilized the expertise of CDPHE staff to assist with this. This was invaluable for checking the researcher against confirmation bias and protecting against observer effect, a type of reactivity that leads to the improvement of the treatment integrity of the person collecting that data (Howard et al., 2013). Protecting this research by not imparting information or bias on the subjects by the act of performing the research and only imparting information when requested by subjects and only presenting facts.

The researcher's table is available for review upon request but was not included in the study to protect against the observer effect and open transparency. A blank table can be found in Appendix G, this is what was presented to the subject matter experts. This also leads to a hole within the research. The researcher works for the Colorado Department of Transportation which has a phase-1, non-standard MS4 permit, there is not a representative of a transportation or a non-standard permit holder in the selection of interviewers.

The methodology required careful planning with both the Colorado Stormwater Council and the Water Quality Control Division. A scope of work was drafted and initially approved by the Colorado

Stormwater Council Post-Construction Committee. The scope of work was highly refined by the clients at CDPHE. The original policy question and methodology changed over a few one-hour meetings with Division clients. The final scope of work dictated the research of the BMP database, research into EPA administered State of New Mexico research, the use of carefully selected subjects to interview to represent a wide cross-section of experts on post-construction control measures from across Colorado and the approval of a Policy Matrix Analysis document in the final proposal which includes the scope of work and time-table (Appendix A).

Policy Analysis Matrix

To conduct an analysis of a public policy or program, one must clearly establish what the problem is and what the goals of a solution are before conducting analysis. How a problem is defined can lead directly to the chosen policy solution (Crow, 2022). As this was an exploratory exercise it was made clear during interviews and follow up questions that assumptions outside of the matrix guidance should be documented with their analysis matrix responses. Policy matrices were sent out two-weeks prior to interviews for the SMEs to review. A significant amount of time during the interview was devoted to clarifying and reinforcing the Policy Analysis Matrix as the primary focus of the study. E-mails were sent to SMEs clarifying that there was an omission in the policy guidance. The omission of this language in the Policy Analysis Matrix Guidance (Appendix D) in regard to effectiveness: where the policy alternatives are effective it is the stated goal of CDPHE to be “specific and measurable” with MS4 permits. Other e-mailed questions were added to the end of transcriptions in a section titled E-mail correspondence. All policy analysis matrices were requested back after the interview process approximately 2-3 weeks after the interview. Matrices were returned to the researcher via e-mail attachment. A blank Policy Analysis Matrix (Appendix G) along with the Policy Analysis Matrix Guidance (Appendix D) describe the researchers approach and limited guidance.

Interviews

All interviews were administered by the researcher. Interviews were recorded with Google Meet™ and used the transcription tool provided by this service. Transcriptions were reviewed for clarity of terms and acronyms, some erroneous (i.e., Umm, Uhh and repetitive) language was removed only to provide clarity and only reviewed against .mp4 (audio visual file format) recordings for accuracy and clarity. SMEs were offered the opportunity to perform the interviews via google meet or in-person in a reserved room with only the researcher and the SME. Interview requests and dates were scheduled 3-4 months in advance. All SMEs filled out and signed the Interview Request Form (Appendix E) and provided a biography (appendix C). Standard interview questions can be found in Appendix F.

Attempts were made to interview administrators from the Environmental Protection Agency (Region-6). This region is responsible for the administration of the State of New Mexico's EPA permitting system (No New Mexico assigned state agency to administer MS4 permits) for comparison of a Federally managed and Colorado MS4 permit requirements.

Results

This is a qualitative study with quasi-quantitative results (Flick, 2007). The subject matter from this study comes from the Scientific/Engineering field with policy research options to address a regulatory compliance uncertainty. As recommended, it needs to be made clear that emerging research from the field of engineering education needs to explicitly address quantitative, qualitative or mixed methods research evaluation criteria (as appropriate) as a cue to readers and reviewers (Borrego et al., 2009). The audience of this research is a mixture of scientists, engineers, policy makers and policy educators. This is primarily a qualitative study utilizing quantitative methods to produce a recommended alternative based on scoring of the policy analysis matrix sheet and supplemented with SME interviews. This is utilizing the method of quasi-qualitative results by analyzing the qualitative data in a quantitative matter to produce results.

Though this was primarily a qualitative study, the researcher did employ some quantitative values in the Policy Analysis Matrix (Appendix H). The use of Triangulation: the combination of different methods, theories data or research in the study of one issue (Flick, 2007) is a core research component. Some participants did not add notes or did not add sufficient notes to the policy analysis matrix. When compiled with research interview questions the matrix table has sufficient data to be a good research document.

The use of a policy matrix to triangulate the results of SMEs was supplemented by qualitative data interviews to help SMEs analyze their policy preferences. This ensured, the triangulation of the qualitative data to reinforce the quantitative Policy Analysis Matrix in a way that would feel familiar to the SME of either a scientific, engineering or policy background. Many of the policy experts selected for this study are accustomed to viewing this particular policy analysis window through a quantitative lens. This approach will also allow quick and impartial analysis of this qualitative data to quickly highlight the preferred policy alternative. An interesting note is the assumption of a null hypothesis or the control variable within the research and in the policy matrix. In environmental policy analysis there is always a no-action alternative. The premise is; if no action is taken, what are the effects of the no action policy. Through discussions with clients there was another alternative that was added to the policy matrix, that of a null situation where the variable in question, MTDs would not be allowed as a policy alternative analysis or the restricted use of MTDs/proprietary technologies policy alternative. No SME chose the no-action or the null policy alternative as a viable solution. Many comments from SMEs expressed gratitude for the inclusion of this alternative as a baseline for comparison. "The one end of the spectrum is do nothing status quo. The other end is let's get rid of everything so we never have to deal with this issue at all" (Seth Brown, NMSA). Consensus in this research was demonstrated by five or more SMEs, providing similar or the same feedback in the interview process or in the analysis of the policy analysis matrix.

TSS Policy Analysis Matrix Summary Table

The status quo policy has the second lowest rating only above the Restricted use of MTD/proprietary technologies policy alternative. This indicates that the current **status quo is not a good option** and action in the form of another policy option is suggested. **A complete restriction of MTDs is the lowest rated policy**. This indicates the need for these devices to fulfill needs within the MS4 community. A common question for the end user acceptability category was, "who is the end user?" or "Is the end-user the MS4s?", the answer provided was yes, the end user is the MS4. This made this question difficult for three SMEs as they were not responsible for an MS4 permit. They did try to answer questions and provide feedback from the perspective of an MS4 Permitees. The highest quantitative score of **18.125** was the **Limited MTD/Proprietary Technologies from STEPP list** policy alternative. The next most recommended alternative with a score of **17.675** is **the Adopt percent removal standards into Colorado MS4 permits** policy alternative. With the highest scores and based on feedback from interviews these are the two recommended policy alternatives. The Matrix summary can be viewed in Appendix H.

> "A nation-wide approval process would be ideal. This will take time and money. Municipalities do not have the expertise needed to make these decisions. Effectiveness of the systems can be tested for different weather conditions, soil types and typical land uses. This should be a more clear, measurable and fair system for all underground manufacturers." (Julianna Archuleta, Adams County)

SMEs were given the other options section within the matrix to propose a policy solution that was not presented as a standard or listed alternative. SMEs did not have the opportunity to review or rate other policy alternatives from other participants. Most alternatives provided are a hybrid of other policy options or slight changes to existing protocols. Only four SMEs of eight that participated added another alternative policy as an option. The summary of these four proposals can be found in (Appendix H).

Common Interview Themes

Google transcription service seemed to work well in the virtual environment when the SME and the interviewer were not in the same room. Video recordings were the best source of data. Questions regarding current use and understanding of MTDs and current practices of selecting an approving had a wide array of answers including: “Manufacturer treatment devices have a wide range of treatment efficiencies, including standalone treatment. That's just one example of where. I think there could be more flexibility in the permit. That would open a door more for MTDs,” (Holly Piza, MHFD).

Requiring Professional Engineering Stamps

A Professional Engineer (PE) stamp as a mechanism for liability protection amongst interviewee with MS4 permit responsibility. Concerning if manufacturers can’t prove they are meeting the permit requirement of 30 mg/L? “If that ever came up, I think that would be a professional engineer liability situation and we'd have to have some legal opinions involved on where that liability falls,” (Erin Powers, Colorado Springs).

Influent Concentration and Particle Size Distribution Specifications

Common themes around the question of current guidance or specification on MTD influent concentrations or specified particle size distribution (PSD) were all unanimous in claiming no influent concentration or PSD are in current guidance criteria. The following statements expand upon this:

> “I just think that there needs to be a consideration of the influent concentrations, when looking at this. I think you can use these together in a way that makes sense. I would look to The Washington Department of Ecology and their testing program as a model for how that could be done.” (Seth Brown, NMSA) Many of the studies in the BMP database were not TAPE quality studies, so I think BMP database results should for sure be taken with a grain of salt. (Craig

> Fairbaugh, Contech) “Which would make the percent removal standard a little more clear and deliverable based on the testing protocol.” (Jake Moyer, Arvada) “I would not put that onus on the manufacturer, the installer in a specification. (The same with particle size) I think it's the job of the state of the jurisdiction. To help identify.” (Seth Brown, NMSA) The policy alternative adopting percent removal standards into Colorado MS4 permits was the second highest rated option. Many SMEs had a similar caveat, “I think a percent removal can be a very effective mechanisms, however it must be accompanied with a standardized way of determining this percent removal. If left solely to manufactures then I am not confident that adequate water quality benefits are achieved. When evaluating this scenario, it was assumed that the state would NOT adopt a verification program.” (Tyler Dell, Longmont)

When asked about proposed solutions to allow MTDs and maintain current water quality standards comments were generally characterized as: further testing, policy change to a percent removal, a nuanced look at verification of the current standard.

> “Every state is going to be different based on erosion and different, particle sizes based on surrounding geology. If there was a STEPP program, I would say it would be better to have it specific for Colorado because the staff is nationwide. but some products may work better on the East Coast, or better over there in the West Coast.” (Jake Moyer, Arvada) “I would change the standard from milligrams per liter to percent removal.” (Jake Moyer, Arvada) The 80 percent TSS standard is “a better way instead of having one number to try to quantify everything. I think it's more nuanced and technically a more sound policy approach.” (Seth Brown, NMSA)

Looking at all the Options

More than one SME pointed out that we have lots of different control measures that can’t treat to the Pollutant Removal Standard that can treat to another standard like Water Quality Capture Volume or

the Runoff Reduction Standard. It was universally proclaimed that it is always better to use these devices or any other treatment in a series or sometimes referred to as a treatment train. Comments regarding the proposed effectiveness of the STEPP program combined with ASTM E64 standards has a common theme that affirmed this use. This is also be born out in the policy analysis matrix and combined with such quotes as:

> “It depends on what their outreach documentation and messaging and marketing is for the program. Effectively. If it's just technical manual white paper on the backend. No, I don't think it'll do a whole lot. I don't think that's if it's some paper that they produce and they put on their website somewhere, and don't really tell people about it or maybe there's one news release. About it then. No, I don't think it would affect be very effective. If however, they develop a useful resource and spend time and effort to disseminate that, I think there's a good chance that, yes, that would be very useful and help standardize but that would require them to spend a fairly significant amount of time and resources on outreach and education, which is not usually a huge portion of Research and Grant dollars. Historically.” (Tyler Dell, Longmont) “I don't know that I have a specific solution but anything that would involve a reference that MS4s could reference or point to document compliance with the standard that's published. I think that would be a good way to go.” (Erin Powers, Colorado Springs) “The easy thing to do is to throw up your hands in the air and just like, all right, everyone gets in, well, that doesn't help water quality, you know, but so I think I think there's a tendency to throw your hands up in the air, like I'm done with this.” (Seth Brown, NMSA)

These comments lead to discussions on lab testing prior to installation of MTDs like the current NJDEP program,

> “The laboratory setting isn't real world. We could get close with laboratory settings, but until you have a field verification of it. You're still. In a hypothetical situation. And that's what we're currently in. Is the hypothetical assembling assuming things like I think there's ways to get the laboratory testing to a point where you feel better about it but not, I don't think I'd ever feel substantially better than that. Oh, this is correct because we have this lab test to show it.” (Tyler Dell, Longmont) “I always advocate for TAPE when we're looking at verifying a filter and looking at 80% TSS, which both NJDEP and TAPE, define 80% TSS, as a filter, I recommend TAPE because it is a field monitoring protocol.” (Craig Fairbaugh, Contech)

More Questions Generated by the Research

There was a general lack of consensus regarding the idea of what organization should tackle the guidance for Colorado. This may be a source of a round-table or conference discussion here in Colorado. What organization should have authority to verify an MTD? What organization should develop guidance? What role do the manufacturers play in verification, approvals, stamping and liability. If we stick with the 30 mg/L standard, should we use a cross-walk to other states verifications systems, will STEPP develop a list we can accept as a State and is defensible. Will STEPP take on the liability or will it fall back to the MS4 Permitees? What liability should the State take on? Where is funding coming from? As my research indicates the Engineering community prefers to talk these things out in conference proceedings and this is a unique Colorado issue. Perhaps this should be talked through at a Colorado Specific Conference with <u>all</u> stakeholders involved.

> “We all agree that there are these shortcomings in this but we feel like that's whatever I'm not trying to but just as an observer of these issues and I have spent a lot of time talking to people from all over the country and you know, I'm on these issues. And I'm just struck by how little consensus there is and some of these topics and more research in these areas I think could only

> help us come to not the right answer but a consensus for the industry that wouldn't help us mature and move forward because who knows what's right or wrong, right? But it's just more of a what can help us move forward." (Seth Brown, NMSA) "I don't think we (MS4s) knew what we were accidentally getting into. Until you implement the standard, it was scary, because you don't have the time (to evaluate) everything that I was evaluating in two or three years." (Juliana Archuleta, Adams County) "We need more research on maintenance. This is kind of a focus of my own master's research." (Craig Fairbaugh, Contech)

Further Research Needs

A common theme expressed was the need for more research beyond sediment capture, things like nutrients, heavy dissolved metals and emerging pollutants like PFAS. SMEs relished the opportunity to discuss hybrid approaches and current opportunities for permit interpretation. The researcher would allow for some discussion but would bring the central theme of the current policy and proposed alternative back to the forefront per good interviewing technique.

> "Well, you could use a HDS Unit for pre-treatment anywhere. I'm specifically talking about the regional standard where you're treating water quality in the stream and there is an enhancement that's required and the permit spells out a very specific type of treatment for that enhancement. And that is the 20:10 rule." (Holly Piza, MHFD)

A sense of urgency to take action to protect water quality and at the same time tear down barriers to implementing permanent control measures was a theme shared by most SMEs, "I think some of it has been hung up on the percent removal versus effluent limit." (Craig Fairbaugh, Contech) This has kept the MTD use in Colorado from being utilized.

A common interview theme was simply asking where did the 30 mg/L TSS standard come from and what was the rationale for using this standard when verification methods at the time NJDEP and

Washington TAPE) used the 80-percent TSS standard? The researcher could only point to MHFD standards and sanitary wastewater permit standards.

Equity

Equity was universally seen as important. Defining how equity played a role to stormwater quality was not unified. This brought up more questions than answers. Common questions regarding equity included: equity between states, equity between MS4 communities both inside Colorado and outside Colorado, equity between the private sector and public sector, equity between low-income and high-income communities. Most SMEs have an inherent understanding of equity as it relates to social impacts, however, were challenged to look at MTDs and see a social inequity relationship.

> "If the use of these becomes more difficult, that would negatively impact redevelopment of some of the smaller parcels and older areas of the city. Oftentimes, these devices are by far the most practical solution for the site. That could negatively impact those areas much more than say, greenfield areas, or areas that have been more recently developed. That have just more room available on the site." (Erin Powers, Colorado Springs) "The haves and have nots. That's, growing between not just advantaged communities and disadvantage communities, but also between small and mid-sized communities and larger phase-1 communities. I think and I would hope that there would be a way and this is what I would like our organization (STEPP) to do is to help to bridge that information and technology transfer as well as bring more investment potential to small and mid-size communities." (Seth Brown, NMSA)

A common equity concern is the current use of NJDEP and Washington TAPE program reliance from other states and MS4s without paying into these testing protocols. This is true of Colorado as the State does not pay into a verification system and relies on the results and work of other States.

Discussion and Recommendations

The journey to find out how Colorado deviated from a percent removal practice standard to a 30 mg/L continues. The researcher had already approached this study with a bias that the volumetric standard was implemented without due diligence and scientific backing. Randi Johnson-Hufford provided the researcher the antithesis of this view and encouraged the research to find a solution beyond one or two policy applications. Through this process the researcher developed an appreciation for the regulatory side of policy analysis.

Attempts to interview administrators from EPA Region-6, which maintain direct regulatory control of MS4 permits within the state of New Mexico. EPA Region-6 was asked to comment on the acceptance of MTDs within the nationally controlled system resulted in the following statement, “EPA does not regulate proprietary/manufactured controls or any type of controls. EPA regulates the water quality of the discharge; therefore, if a control measure is not as effective then the municipality will have to re-evaluate the control measure. The measure may have to replaced or an additional measure may have to be added to improve the water quality of the discharge.” (EPA, Region-6) This represents a significant cost and liability to any MS4 considering installation of an MTD, if the structure is found to be deficient in treatment there is the cost of replacement and potential non-compliance costs. This represents an additional need to have a verification system that is consistent with national protocols.

There is compliance uncertainty associated with having the state of Colorado and national testing standards evaluating MTDs at different standards. Using both interviews (Qualitative and the Matrix (Semi-quantitative) allows for transformation of the data analysis through another approach (Tashakkori & Teddlie, 2009, as cited in Flick, 2007) The concept of integrating qualitative and qualitative approaches goes one step further, aiming at developing integrated research design and at integrating qualitative and quantitative results (Kelle & Erzberger, 2004, as cited in Flick, 2007). This is the idea of triangulation using qualitative information to check the quantitative results and vice-a-versa (Flick, 2007). The primary research tool for this research was the TSS policy analysis matrix. This tool allowed

SMEs time and space to ponder their responses and evaluate policy alternatives. Interviews helped to reinforce or clarify thoughts and ideas while utilizing the qualitative narrative format of an interview where thoughts could be explored with another individual. The tertiary benefit of the triangulation approach is it allowed the SMEs two different avenues to express their opinions. This approach of triangulation is a preferred research method.

Recommendations

Based on the interviews and identified limitations in this study, the recommendations center around the need for further research. Recommended areas for future research are presented according to whether they were mentioned in the interviews, in the policy analysis matrix table or identified by the researcher.

Future Research Areas from the Interviews

No unified theme of cost-saving or research funding opportunities presented during the research interviews; however, a common theme was a need for further research. Funding research opportunities to ensure MTDs can remain part of the toolbox of effective stormwater quality is at hand and,

> Congress has provided $3 million in initial funding for the establishment of three to five Centers of Excellence for Stormwater Infrastructure Technologies (CESITs), a new program authorized in the Infrastructure and Investment in Jobs Act (IIJA) of 2021. Beyond this initial funding, the appropriations packaged signed into law provides for at least $3 million in funds for the CESITs for four additional years for a total of a minimum of $15 million over a five-year period. The National Municipal Stormwater Alliance (NMSA) and the Water Environment Federation (WEF) worked over multiple years to advocate for funding to establish and support the CESITs (NMSA, 2023).

This research helps provide evidence that Colorado can take advantage of these funds by partnering with organizations like NMSA and can prove environmental leadership by having members of the ASTM E64 committee from the Colorado MS4 permitting realm as national stakeholders.

Within the interview questions was the use of the term volumetric vs a percent removal. This was often questioned by SMEs as both rely on volumes. The correct terminology is weight-based vs percent based TSS removal. This should be made clear to future researchers when working with Engineers who generally have difficulties overlooking mistakes or errors in research methods.

Surprisingly little peer reviewed research is being conducted comparing MS4 regulatory requirements. This research could be expanded by surveying the entirety of the Colorado Stormwater Council or all MS4 permitees. This could garner more Colorado policy specific data. Alternately utilizing the network of members of National Municipal Stormwater Alliance to perform a survey utilizing the policy analysis matrix as a backbone for future policy research. The use of interviews has allowed the efficient exploration of both Colorado and to a lesser extent a national view. Surveys should consider audiences of a particular region or state when conducting surveys. The Colorado Stormwater Council will be the most effective and efficient means of determining Colorado views and most effective dissemination network to work on policy while allowing an organization like NMSA that already collects survey information in the form of the State of the Stormwater reporting system. It will be important for CDPHE to either lead, sponsor or heavily participate in this effort.

A recommendation for further research is utilizing part of Regulation-61.10(e) of the Colorado Clean Water Act under their anti-backsliding policy, allows for new information and correction of certain mistakes to be bases for an exemption from the anti-backsliding requirements for technology-based effluent limits. The Commission revised the anti-backsliding provisions contained in Section 61.10(f) to allow the same approach for water quality-based effluent limits. This change is consistent with the

federal requirements (CDPHE, 2020). Additionally, the Water Quality Control Division could use section 61.10(e) and the number of exceptions that are listed in that section to allow the Water Quality Control Division to justify a permit change to align with national testing standards. The logic of following a standard that no other state is testing, verifying or regulating is not helping Colorado MS4 permittees. The research is clear, the desire to use a coalesced national standard is wanted and needed.

> There is a research gap between policy research and engineering research that has been documented as a shortfall with little literature and research that is actively bridging the gap. This research helps to bridge this gap with Colorado specifically regarding TSS removal as a pollution removal standard within Colorado MS4 permitting systems. This research could be used as a template for research in other States looking at comparisons with other states and national standards in stormwater quality regulation, well beyond the issue of TSS policy research. I would consider using this in the future. or a form of this (matrix) if that's appropriate because this is really helpful." (Seth Brown, NMSA)

Other Identified Areas for Future Research

Discrepancies in understanding the Policy Analysis Matrix (Appendix G) and subsequent Policy Matrix Guidance (Appendix D). SMEs may have not read the guidance document carefully so there is a chance that confusion in the rating system might have introduced scoring errors. The researcher asked in the interviews if they had any questions regarding either document (see Appendix F).

Further research and review of the Policy Analysis Matrix Summary table could identify weighted categories for specific users. This research weighted all categories equally for comparison. This would need to be explicitly spelled out in any methodology section of future research to be clear about weighing one category over another.

A national program like STEPP can help alleviate equity concerns regarding who is paying for the monitoring, testing and verification of MTDs. This can reduce cost by incorporating economies of scale and allowing participation from smaller MS4s with less tax funding or lower development rate funds.

Finally, a review of proposed hybrid policy solutions in the Policy Analysis Matrix Summary (see Appendix H) shows that half of the SME participants offered up an alternative or hybrid policy. Future research could be focused on analyzing these solutions against other proposed policy solutions. No SME could review the hybrid policy proposal from another SME thus further research into proposed hybrid solution is warranted.

Conclusion

This research helped confirm the concerns Colorado MS4 permitees have with implementation and compliance of the TSS pollutant removal standard in Colorado MS4 permits by analyzing different policy alternatives and using triangulation of qualitative and quantitative methods to address the implementation of the compliance concerns while protecting water quality standards for the citizens of Colorado. It ultimately identified two strong policy alternatives, a **Limited MTD/Proprietary Technologies from STEPP list** policy alternative and to **Adopt percent removal standards into Colorado MS4 permits** policy alternative.

One resounding call to action that was stated is the need for more research on MTDs post-installation and indeed for all permanent control measures as it concerns operation and maintenance of facilities. A multi-disciplinary team of hydraulic engineers, stormwater scientists and policy analysts should be involved with future studies on this subject. Having an expanded team will increase the depth of research on all aspects of this engineering, scientific and policy analysis research.

We continue to install permanent stormwater control measures with most development projects but how is the operation and maintenance of these control measures affecting the

performance to ensure stormwater quality? As we debate the use of a standard testing measure, manufactures are determining that the lack of clear guidance and acceptance in Colorado makes this a bad community for business. This leaves MS4 practitioners in Colorado without a key tool in the BMP toolbox for small and confined sites like transportation capital projects. This will increase the cost for all taxpayers if we do not have clear achievable guidance for MTDs. The need for policy, engineering and scientific research is approaching, as is the need to Explore barriers to this type of research and investigation.

References

Barret M. (2008). *Comparison of BMP performance using the international BMP database.* Journal of Irrigation and Drainage Engineering, American Society of Civil Engineers. 134(5): 556-561.

Brown S. (2020). *The stormwater testing and evaluation for products and practices (STEPP) status report and strawman document.*

Borrego M., Douglas E. and Amelink C. (2009). *Quantitative, qualitative, and mixed research methods in engineering education.* Journal of Engineering Education (1) 53-66.

Birkland T. (2020). *An introduction to the policy process.* New York, New York: Routledge, Publishing.

Bockenholt U., Cherneve A. and McShane B., (2017). Journal of Consumer Psychology, 25(2): 333-358. *When are consumers most likely to feel overwhelmed by their options?. Retrieved from: https://insight.kellogg.northwestern.edu/article/what-predicts-consumer-choice-overload*

CDPHE, Colorado Department of Public Health and Environment. (2023). *Water quality website.* Retrieved from: https://cdphe.colorado.gov/water-quality

CDPHE, Colorado Department of Public Health and Environment. (Revised 2019). *Colorado department of transportation permit COS050000, Stormwater discharges with municipal separate storm sewer systems (MS4).*

CDPHE, Colorado Department of Public Health and Environment. (2011). *City of Colorado Springs permit COR000004, Authorization to discharge under the Colorado discharge permit system.*

CDPHE, Colorado Department of Public Health and Environment. (2008). *Metro wastewater reclamation district permit COR0026638, Colorado Discharge Permit System (CDPS).*

Colorado Department of Public Health and Environment. (2021). *General permit COR090000, Stormwater discharges with municipal separate storm sewer systems (MS4).*

CDOT, Colorado Department of Transportation. (2021). Drainage Design Manual, *Permanent water quality, Chapter-16,* 16-32.

CSC, Colorado Stormwater Council. (2023). *Colorado stormwater council main webpage.* Retrieved from: https://colorado-stormwater-council.org/

Crow D. (2022) *Example evaluation matrix and definition criteria/goals.* Class document for PUAD 5005, Policy Process and Democracy.

EPA, Environmental Protection Agency. (2014) Memorandum, Revisions to the November 22, 2002, memorandum "establishing total maximum daily loads wasteload allocation for stormwater sources and NPDES permit requirements based on those wasteload allocations. Retrieved from: epa_memorandum_establishing_tmdl_wlas_for_stormwater_sources_2014_00000002.pdf

Dell Tyler (Civil Engineer at City of Longmont, former director of the Colorado Stormwater Center).

Personal discussion, December 2020.

Fink J, and Anastasio A. (2012). *Washout testing comparison of hydrodynamic separators.* American Society of Civil Engineers, World Environmental and Water Resources Congress 2012: Crossing Boundaries. Retrieved from: https://ascelibrary-org.aurarialibrary.idm.oclc.org/doi/epdf/10.1061/9780784412312.085

Howard M., Burke R. & Allen K. (2013). Behavior Modification, 37(4) 490-515. *An evaluation of the observer effect on treatment integrity in a day treatment center for children.* DOI: 10.1177/0145445513486801. Sage Publications

Herzog, Skuyler P., Eisenstein, William A., Halpin, Brittnee N., Portmann, Andrea C., Fitzgerald, Nicole J. M., Ward, Adam S., Higgins, Christopher P., & McCray, John E. *Co-Design of Engineered Hyporheic Zones to Improve In-Stream Stormwater Treatment and Facilitate Regulatory Approval*. United States. https://doi.org/10.3390/w11122543

J. C. -L. Jones, G. Minton, J. Nabong, S. Hasenin (2011). Development of municipal separate storm sewer system (MS4) numeric limits for constituents of concern and evaluation of proprietary best management practices (BMPs) for the city of San Diego, CA. *American Society of Civil Engineers, World Environmental and Water Resources Congress: Bearing Knowledge for Sustainability.* https://ascelibrary-org.aurarialibrary.idm.oclc.org/doi/10.1061/41173%28414%2966

Kayhanian, M., Roseen, M., Lenhart, J. & Williams, G. (2009). Potential Data Analysis Methodology to Evaluate the Performance of Manufactured BMPs. In *World Environmental and Water Resources Congress 2009: Great Rivers* (pp. 1-10).

Kiparsky, M.; Sedlak, D.L.; Thompson, B.H.; Truer, B.; Truer, B. (2013). *The innovation deficit in urban water: The need for an integrated perspective on institutions, organizations, and technology*. Environ. Engineering and Science. 30, 395–408.

MHFD, Mile High Flood District. (2022). Urban storm drainage criteria manual volume-3. *Draft update of T-11 on manufactured treatment devices.* https://mhfd.org/wp-content/uploads/2022/03/MTD_3-28-22_ForStakeholders.pdf

MHFD, Mile High Flood District. (2012). Urban storm drainage criteria manual volume-3. *T-11 on manufactured treatment devices. https://mhfd.org/wp-content/uploads/2021/01/01_USDCM-Volume-3.pdf*

New Jersey Department of Environmental Protection, (2023). Stormwater manufactured treatment devices. Retrieved from: https://dep.nj.gov/stormwater/stormwater-manufactured-treatment-devices/

NMSA, National Municipal Stormwater Alliance. (2023). NMSA, *WEF Celebrate federal funding of centers of excellence for stormwater infrastructure technologies.* Retrieved from http://nationalstormwateralliance.org/nmsa-wef-celebrate-federal-funding-of-centers-of-excellence-for-stormwater-infrastructure-technologies

Peterien J., Buechter M. (2011). The “ballistics test”: proprietary BMPs and metropolitan St. Louis sewer

district BMP performance verification. *American Society of Civil Engineers, World Environmental and Water Resources Congress: Bearing Knowledge for Sustainability***.** https://ascelibrary.org/doi/abs/10.1061/41173%28414%29375

U.S. Environmental Protection Agency. (2022, July 7). *Substance registry service, Total suspended solids.* Retrieved from https://www.epa.gov/sustainable-water-infrastructure/asset-management-programs-stormwater-and-wastewater-systems

U.S. Environmental Protection Agency. (2022, July 7). *Stormwater discharges from municipal sources.* Retrieved from: https://www.epa.gov/npdes/stormwater-dischargesmunicipalsources#:~:text=An%20MS4%20is%20a%20conveyance,not%20a%20combined%20sewer%2C%20and

Nickerson S. (1998). Confirmation bias: a ubiquitous phenomenon in many guises. *Rev. Gen. Psychol.* **2,** 175–220.

Smolek A., Anderson A. & Hunt F., (2018). Journal Environmental Engineering, 144(2), American Society of Civil Engineers. *Hydrological and water-quality evaluation of a rapid-flow biofiltration device.* DOI: https://doi.org/10.1061/(ASCE)EE.1943-7870.0001275

Strecker E., Quigley M. & Urbonas B. (2003). *American Society of Civil Engineers, World Environmental and Water Resources Congress: Results of analyses of the expanded EPA/ASCE national BMP database.* World Water & Environment Resources Congress 2003. https://ascelibrary-org.aurarialibrary.idm.oclc.org/doi/abs/10.1061/40685%282003%29339

Urban Stormwater BMP Performance Monitoring, (2009). Section 1.5. *The international BMP database.* Retrieved from: *https://static1.squarespace.com/static/5f8dbde10268ab224c895ad7/t/604926dae8a36b0ee128f8ac/1615406817379/2009MonitoringManualSingleFile.pdf*

Washington State Department of Ecology, (2023). Emerging stormwater treatment technologies (TAPE). Retrieved from: https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

Water Quality Control Commission, 5CCR 1002-61. *Regulation 61.* (Revised 2020).

State of Indiana, (2015). *Wastewater Study Guide Sheet.* Retrieved from: https://www.in.gov/idem/cleanwater/files/wastewater_cert_study_guide_formula_sheet.pdf

Appendix A
Proposal and Scope of Work

University of Colorado Denver

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To:
Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division (WQCD)

Colorado Stormwater Council (CSC)

Introduction
Please accept this proposal for services from Jeremiah Unger on behalf of the School of Public Affairs at the University of Colorado Denver. The work outlined in this proposal will be provided on a volunteer basis. The goal is to develop a survey and summarize the data from Colorado stormwater permittees, and to develop a report for delivery to the Permits Unit of the Water Quality Control Division at CDPHE. This effort fulfills part of a capstone project through the University of Colorado Denver to help Jeremiah Unger obtain his Masters in Public Administration (MPA) through the School of Public Affairs. The effort would help the regulated stormwater quality community and stormwater quality regulators determine a specific course of action or if action is needed. This will require a project sponsor and provide independent review from a member of CDPHE-WQCD and a member of the CSC (Please see the project background below).
As a current state employee with 15-years of Municipal Separate Storm Sewer System (MS4) experience through CDOT Phase 1 permit and other Phase 2 permits. I bring access to the relationships I have developed with other MS4 municipalities through the CSC. I am uniquely qualified and placed to assist the Stormwater Community in researching the issue below.

Project Background
The state of Colorado does not have a verification or certification system to test the effluent concentrations to meet the current MS4 pollutant removal permit standard of 30 mg/L. Currently permittees must rely on third-party testing protocols from Washington State or New Jersey. These testing entities report the pollutant removal standard as the surrogate reporting measure, total suspended solids (TSS) with a percent removal rate. This percent removal rate was previously written into MS4 permits in Colorado. This project would help investigate the policy implications of aligning Colorado TSS standards with national standards. Currently MS4 practitioners must rely on data from manufacturers. It is difficult to determine the validity of the pollutant removal claims from these manufacturers since they convert from the testing percent rate from Washington and New Jersey to the effluent limit of 30 mg/L for Colorado. This creates ambiguities about whether or not permittees are meeting the pollutant removal standard in their MS4 permits.

Problem Statement
Explore the policy implications regarding aligning Colorado MS4 TSS removal requirements with national standards.

Statement of Work

1.) Task 1. Regulatory review of existing (TSS) Pollutant Removal Standard in Colorado MS4 permits.
   a.) Coordinate with CDPHE-WQCD to find staff that can review and accept findings
   b.) Research State and National recommendations for testing and review Pollutant Removal Standard/Total Suspended Solids (TSS) for proprietary systems. Investigate and perform literature reviews of: International Stormwater BMP database, National Municipal Stormwater Alliance, Other state programs and standard practices of the Environmental Protection Agency (specifically EPA region 6 for New Mexico). Include this research in the final summary report.
   c.) Review of anti-backsliding language of regulation-61 of the Colorado Discharge Permit System

2.) Task 2. Develop interview questions for national and Colorado specific stormwater subject matter experts (SME). Disseminate survey questions to MS4 permittees and SME partially utilizing the Colorado Stormwater Council network of members. The interview questions will explore policies ranging from new guidance, innovative ideas to meet TSS removal requirements and/or permit changes
   a.) Develop a list of SMEs that represent a wide spectrum of impacted users of the TSS standard. Reviewed and accepted by CDPHE-WQCD
   b.) Develop interview questions and policy analysis matrix for potential SMEs, regarding guidance and solicitation of ideas for meeting the (TSS) Pollutant Removal Standard in Colorado
   c.) Review the survey with CPDHE-WQCD prior to dissemination
   d.) Finalize the survey and disseminate to selected SMEs

3.) Task 3. Summarize interview data and develop recommendations based on the survey findings to CDPHE-WQCD
   a.) Develop a summary of the interview results
   b.) Develop a summary matrix of policy analysis
   c.) Develop a report with survey summaries and recommendations to CDPHE-WQCD

Summary of Deliverables

- List of SME for interviews reviewed and accepted by CDPHE-WQCD
- Interview questions reviewed and accepted by CDPHE-WQCD
- Policy analysis matrix
- Summary report of findings and recommendations
- Research materials of State and national Pollutant Removal Standards documented in the summary report

Timeline

Results and final deliverables should be delivered by March 2023 for review and acceptance by CU Denver administration by April 2023.

Sincerely,

Jeremiah Unger
Graduate Student, School of Public Affairs
University of Colorado Denver

Appendix B
List of Subject Matter Experts

University of Colorado Denver

Jeremiah Unger
University of Colorado Denver School of Public Affairs

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o 303 513 3927
jeremiah.unger@ucdenver.edu
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November 4th, 2022

To:
Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division (WQCD)

RE:
Interview list of Subject Matter Experts (SME) for the Colorado Pollutant Removal Standard Policy Exploration

1. Erin Powers, MS4 Compliance Program Manager for City of Colorado Springs (Updated 3/30/23)
2. Carrie Gudorf / Josh Martinez, Regulatory Program Managers for Mesa County
3. Craig Fairbaugh, Regional Regulatory Manager for Contech Engineering Solutions
4. Holly Piza, Research and Development Director for Mile High Flood District
5. Jake Moyer, Stormwater Administrator for City of Arvada
6. Juliana Archuleta, Stormwater Administrator for Adams County
7. Seth Brown, Executive Director of National Municipal Stormwater Alliance
8. Tyler Dell, Civil Engineer II for City of Longmont
9. (Alternate) Chris Olson, Senior Water Resources Engineer at Wright Water Engineers
10. (Alternate) Lisa Knerr, Environmental Program Manager for Arapahoe County

Jeremiah Unger
Graduate Student, School of Public Affairs
University of Colorado Denver

Appendix C
Participant Biographies

Carrie Gudorf,

Is the Regulatory Programs Manager for Mesa County. She has been with the County for 10 years and is responsible for administering the Separate Storm Sewer (MS4) Program, Floodplain Management and multiple facets related to water quality programs at Mesa County. Carrie graduated from Fort Lewis College in Durango Colorado with a B.S. in Biology and a minor in Chemistry. Carrie has worked for both the private and public sectors and has over 15 years in water quality and stormwater compliance experience.

Craig Fairbaugh,

Regional Regulatory Manager for Contech Engineered Solutions where he works with state and municipal agencies to achieve compliance with stormwater manufactured treatment devices. Prior to his regulatory role, Craig was a design engineer for Contech where he provided design assistance to projects in over 30 states. He has a B.S. and M.S. degree in Civil & Environmental Engineering from Portland State University and is an active researcher. Research topics include investigating the maintenance and long-term performance of SCMs and developing testing protocols for stormwater filtration media. Craig is also a member of the ASCE EWRI Urban Water Resources Research Council and chair of the EWRI Stormwater Media Filtration Committee.

Erin Powers,

A water resources engineer with the City of Colorado Springs Stormwater Enterprise. A Colorado Springs native, Erin received an undergraduate degree from Harvey Mudd College and a master's degree in Civil Engineering with a focus on Water Resources from Kansas State University. Erin joined the City in 2016 after working in the private sector as a civil engineer. She is currently the Stormwater Compliance Program Manager and was selected by Mayor John Suthers as the 2020 City of Colorado Springs Employee of the Year. Erin served as the technical lead for the City of Colorado Springs in recent settlement negotiations with the EPA, DOJ, CDPHE, and others.

Holly Piza,

Is the Research and Development Director with Mile High Flood District (MHFD) in Denver, Colorado where she directs research and development efforts for the flood district. She has 25 years of experience in water resources engineering. Prior to joining MHFD, she spent 12 years as a consulting engineer and served as the acting Western Region Water Resources Practice-Center leader for Short Elliott Hendrickson.

She has been involved on a national level with ASCE EWRI for the past 14 years and co-edited a book published by ASCE titled, *Cost of Maintaining Green Infrastructure*. As a member of EWRI, she has been active in several councils including serving as Chair of the Municipal Water Infrastructure Council (MWIC). Ms. Piza is currently serving on EWRI's Governing Board as Past President.

Ms. Piza has a Bachelor of Science in Environmental Engineering from the University of Florida and a master's in public administration from the University of Colorado.

Jake Moyer,

Is the Stormwater Administrator for the City of Arvada. Jake is also responsible for Arvada pesticide permitting, oil and gas permitting and air quality for their environmental programs. In 2018, Jake worked at the City of Westminster as an inspector for their MS4 permit. Jake obtained his bachelor's degree from Metropolitan State University in Environmental Science with a focus on water and hydrology in 2016.

Josh Martinez,

Is the Stormwater Coordinator for Mesa County and is responsible for administering, implementing, and enforcing the Municipal Separate Storm Sewer (MS4) Program. He graduated Colorado Mesa University with a B.S. in Environmental Science and Technology. He has worked in both the private and public sector for a combined 8 years in water quality and stormwater compliance experience. His passion for water quality has led him to pursue a M.S. in Hydrology and Water Resource Management at the University of Oklahoma.

Juliana Archuleta,

Is the Stormwater Administrator for Adams County since 2014. Pollution prevention work started at the City of Brighton, Utilities Department in 2006. Stormwater Utility fees were adopted at both municipalities during her employment. Environmental Engineering degree from her hometown Buenos Aires, Argentina. Passionate for protecting the environment. Spanish speaker. Interested in moving her career to Sustainability to continue making a difference.

Tyler Dell,

Civil Engineer working with the City of Longmont. Tyler is specifically working in the Stormwater Quality Program and focuses on urban stormwater and using green infrastructure and low impact development to mitigate the impacts of urbanization. Tyler is also involved with several organizations such as the Colorado Stormwater Council, the Colorado Stormwater Center, the Urban Watershed Research Institute and others. Through his job and organizational involvement, Tyler is passionate about improving stormwater quality in Longmont and coordinating with others across Colorado to continue to learn and advance the stormwater field.

Seth Brown.

Has over 25 years of experience in the water sector and is the Principal and Founder of Storm and Stream Solutions, LLC, a consulting firm providing a range of services from policy and alternative project delivery analysis in the stormwater sector to facilitation and training services focused on stormwater topics. He was the Director of Stormwater Programs at the Water Environment Federation from 2010-2015 and is currently the Executive Director of the National Municipal Stormwater Alliance (NMSA), which is a 501.c.3 representing stormwater-focused organizations in 25 states across 9 of the 10 U.S. EPA regions with a network that is comprised of over 4,400 MS4s.

Seth has a Ph.D. in civil engineering from George Mason University with a research focus on socio-economic modeling of incentive-based investments of green stormwater infrastructure on private properties. He leads courses in Green Infrastructure and Innovative Water Partnerships at Virginia Tech and the University of Maryland at Eastern Shore and is a licensed professional engineer in the state of Maryland.

Appendix D
Policy Analysis Matrix Guidance

University of Colorado Denver

To:
Selected Interviewees
From: Jeremiah Unger, School of Public Affairs at the University of Colorado Denver
Date: February 24, 2023
Subject: TSS removal within Colorado MS4 Permits

Total Suspended Solids (TSS) Removal Standard within Colorado Municipal Separate Storm Sewer System (MS4) Permits Policy Analysis Matrix Guidance

Background
The state of Colorado does not have a verification or certification system to test the effluent concentrations to meet the current MS4 pollutant removal permit standard of 30 mg/L[5]. Currently permittees must rely on third-party testing protocols from Washington State or New Jersey. These testing entities report the pollutant removal standard as the surrogate reporting measure, total suspended solids (TSS) with a percent removal rate. This percent removal rate was previously written into MS4 permits in Colorado[4]. This matrix helps determine Colorado specific policy alternatives for a select group of experts. Currently MS4 practitioners must rely on data from manufacturers. It is difficult to determine the validity of the pollutant removal claims from these manufacturers since they convert from the testing percent rate from Washington and New Jersey of percent removal to Colorado's pollutant removal standard of the event mean concentration effluent limit of 30 mg/L for Colorado. This creates ambiguities regarding whether permittees are meeting the pollutant removal standard in their MS4 permits.

Colorado State University (CSU) is the State of Colorado's University Extension service. As a subsidiary of CSU, the Colorado Stormwater Center is the ideal candidate with the only large-scale hydraulic lab in the state of Colorado. And thus may be the only realistic choice for testing and verifying third party claims of 30mg/L TSS removal if this was an option for Colorado. Currently, research indicates that CSU is currently not willing to take on this effort. Without Colorado specific testing Colorado must rely on manufacturer claims or Washington/New Jersey for verification of manufactured treatment devices for stormwater quality.

Currently anxiety exist among Colorado stormwater MS4 permittees regarding the compliance of selected manufactured treatment devices to meet current 30mg/L TSS standards. While the State of Colorado does not have a verification program the National Municipal Alliance (NMSA) through Stormwater Testing and Evaluation for Products and Practices (STEPP) is pursuing a program at a national level for this type of testing protocol. This offers a way for Colorado to pay into a program and demonstrate equitably paying for

verification of these Manufactured Treatment Devices (MTD)s. Filling out this Microsoft Excel™ Policy analysis matrix will help guide research and recommendations for Policy alternative to this issue. Listed below are the standard wastewater treatment formulas for volumetric and percent removal of TSS for reference.

TSS Percent Removal Formula

$$\text{TSS removal efficiency, \%} = \left(\frac{\text{Influent TSS} - \text{Effluent TSS}}{\text{Influent TSS}}\right) \times 100\%$$

Figure 1

TSS Volume Removal Formula

$$\text{TSS test results, mg/L} = \left(\frac{\text{Net dry weight, mg}}{\text{Sample volume, mL}}\right) \text{ X 1000 mL/L}$$

Figure 2

List of terms and acronyms

- **Total Suspended Solids (TSS)** - The weight of solids remaining after a well-mixed sample is filtered through a standard glass filter and the suspended portion is dried to a constant weight at 103-105 deg C (EPA, 2022).
- **Stormwater Testing and Evaluation for Products and Practices (STEPP)** - Initiative seeks to improve water quality by accelerating the implementation and adoption of innovative stormwater management technologies by removing current barriers to innovation, creating regulatory confidence, minimizing duplicative performance evaluation efforts, and establishing a common framework for testing and evaluating both public domain and proprietary stormwater control measures.
- **Manufactured Treatment Device (MTD)** - Include many different types of proprietary devices that use various treatment processes and designs to remove targeted pollutants. In Colorado targeted pollutants are usually sediment which is measured by TSS.
- **Municipal Separate Storm Sewer System (MS4)** – An MS4 is a conveyance or system of conveyances that is:
    - owned by a state, city, town, village, or other public entity that discharges to waters of the U.S.,
    - designed or used to collect or convey stormwater (e.g., storm drains, pipes, ditches),
    - not a combined sewer, and
    - not part of a sewage treatment plant, or publicly owned treatment works.
- **National Municipal Stormwater Alliance (NMSA)** - A 501(c)(3) with state and regional members made up of Municipal Separate Storm Sewer System (MS4) permittees. NMSA is devoted to supporting MS4 communities, helping them tackle

stormwater challenges so that together we can achieve our vision of providing clean water for the nation.

- **Colorado Department of Public Health and Environment (CDPHE)** – For the purposes of this memo CDPHE will refer specifically to the Water Quality Control Division within the department.
- **Colorado Stormwater Center** - The Colorado Stormwater Center provides education, training and research opportunities with the goal of maintaining and improving the health of lakes, rivers and streams through proper stormwater management.
- **Colorado Stormwater Council (CSC)** - An organization of local MS4s, comprised of cities, counties, and special districts throughout the state Colorado with a mission to effectively protect and improve stormwater quality through collaboration, resource sharing, local partnerships and the focused efforts of special committees.

Problem

What are the policy implications of various approaches to addressing the differences between Colorado MS4 TSS removal requirements and national standards?

Alternatives

Six policy alternatives were reviewed and analyzed with help from the clients at the Colorado Stormwater Council and Water Quality Control Division of CDPHE. There is also a seventh row that is available to list other policy ideas not listed.

The alternatives are listed below:

- Status Quo, No action alternative
- Crosswalk from mg/L to % removal
- Limited MTD/Proprietary Technologies from STEPP list
- Colorado policy guidance and interpretation of existing standards
- Adopt percent removal standards into Colorado MS4 permits
- Restricted use of MTD/Proprietary Technologies
- Other ideas (Please feel free to add ideas or policy alternatives to this section, please make sure you score your idea against other proposed policies)

Analysis criteria

While there are many possibilities of selection criteria and many possibilities of alternatives, the purpose of this matrix is to succinctly list the best policy alternatives based on logical research. The criteria for analyzing the policy alternatives are listed below:

- **Cost Effectiveness (Efficiency)**

  The criteria of cost effectiveness deal specifically with the success of a potential policy alternative and its direct relation to the financial cost of the policy. The more effective the policy alternative, and the lower the policy cost, the higher the policy will rate on the continuum.
- **Water quality benefits**

  Determining how effective a standard or policy will be at protecting water quality.

- **End user acceptability**
  The acceptability of a policy by permittees that must rely on information to determine if a control measure is acceptable to meet MS4 permit requirements.
- **Effectiveness**
  A policy alternatives effectiveness is measured by whether it is successful at achieving the policy goals that were established.
- **Equity**
  Equity establishes the variety of stakeholders given a specific policy. Equity determines whether the burden of a policy alternative is bore by a small segment of the population or a larger, more diverse segment. The more diverse and larger the distribution, the higher on the continuum the Equity score will rate. Equity between states is of primary concern.

Analysis of alternatives and recommendations
These cells are formatted with text wrapping so please do not limit your comments to the size of the excel cell. Please use this field to add ANY comments and if this is a preferred policy recommendation, please take some time to explain why.

Quantitative scoring fields:
Please make sure you reflect and score each policy alternative. The only wrong answer is not filling out a score and providing valuable information for this study.
Please note that all field start with the Low score. This is to highlight the scoring field.

Quantitative scoring table:
High = 3
Moderate/High = 2.5
Moderate = 2
Moderate/Low = 1.5
Low = 1

Note: the lowest possible quantitative score is = 5
Note: the highest possible quantitative score is = 25
Note: the higher the score, the better the criteria is met by that policy alternative.
These quantitative scoring fields will help users identify how they have ranked each policy alternative and will allow fast efficient comparisons with other interviewee scores.

If you have any questions, please contact the primary researcher, Jeremiah Unger, at jeremiah.unger@state.co.us or (303) 513-3927. I can also provide a sample of the policy analysis matrix upon request.

This matrix and supporting interviews will be the backbone of this research.
Thank you for taking the time to complete the Matrix.

Appendix E
Interview Request Template

University of Colorado Denver

Jeremiah Unger
University of Colorado Denver School of Public Affairs

6884 S. Broadway | Centennial, CO. 80122
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jeremiah.unger@ucdenver.edu
jeremiah.unger@state.co.us

March 9, 2023

RE: Colorado Pollutant Removal Standard Policy Exploration Survey

Dear XXXX,

I am currently a graduate student in the Master of Public Administration program at the University of Colorado Denver's School of Public Affairs. As part of the program requirements, I am completing a capstone research project in collaboration with the Water Quality Control Division. I would like to invite you to participate in an interview pertaining to the Pollution Removal standards within the Colorado Municipal Separate Sewer System (MS4) permitting system.

You were selected for this process because you were identified as a subject matter expert in the area of MS4 permit compliance and implementation. The goal in choosing participants based on this single criterion is to gather a variety of perspectives, including those from large and small MS4s, industry representatives, and stormwater management experts. This will provide a robust dataset for this research regarding the pros and cons of various policy considerations.
Your expertise can help investigate the policy potions and implications of how to ensure a particular standard for pollutant removal of stormwater control measures, including a national verification system.

I will administer the one-on-one interview either in person or via a virtual meeting platform (whichever you prefer). The interview will take approximately one hour with time for questions. I will record the interview to assist with documenting answers and ensure accuracy. You may request a copy of this recording for your records. The interview questions will be sent out in advance for your consideration, no later than 3- weeks before your scheduled interview. A policy analysis matrix will also be sent at this time; I am requesting that this be filled out and emailed to jeremiah.unger@state.co.us at least two weeks preceding our interview date, though this matrix is not required to participate in the interview.

I welcome your response via email at your convenience.

With warm regards

Jeremiah Unger

Jeremiah Unger
Graduate Student, School of Public Affairs
University of Colorado Denver

INFORMED CONSENT FORM

☐ I, _____, understand what my participation in this research will entail, and I agree to be interviewed and consent to having my interview recorded. I also understand that I have the right to end the interview and revoke this consent at any time.

☐ I, _____, consent to waive confidentiality and allow my name to be used in association with my interview responses. I understand that I have the right to revoke this consent at any time. I also understand that I do not need to waive confidentiality to participate in this research and that without this consent, the researcher will work to ensure the confidentiality of my participation and interview responses.

Signed_____ **Date** _____

If you have any questions, please contact the primary researcher, Jeremiah Unger, at jeremiah.unger@state.co.us or (303) 513-3927. You may also contact the advisor of this capstone research, Dr. Jennifer Hooker, at jennifer.hooker@ucdenver.edu.

Appendix F

Standardized Interview Questions Template

University of Colorado Denver

Jeremiah Unger
University of Colorado Denver School of Public Affairs

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jeremiah.unger@state.co.us

April 4, 2023

RE: Colorado Pollutant Removal Standard Interview Questions

Purpose:
This is a qualitative research interview. While most of the standard questions and the general theme of the interview can be presented in this document. I reserve the right to present follow-up questions, clarifying questions and to dig into comments and themes deeper. To be an effective interviewer, the subject must be researched and understood and there must be room to explore with follow up questions. This is the nature of a qualitative interview that is exploratory in its nature. Per, Svend/ Kvale "The qualitative stance involves focusing on the cultural, everyday and situated aspects of human thinking, learning, knowing, acting and ways of understanding ourselves as persons".
This is primarily a listening exercise.

Interview Questions:
Introductions, Greetings, Sound and Audio Check, Logistics

Can you confirm your agreement to be recorded and to have this interview transcribed?

Start Google meet with recording and audio transcription.

XXXX can you please confirm your consent to use your interview and transcription in my Graduate research study for the Master of Public Administration program at the University of Colorado Denver's School of Public Affairs on behalf of the Colorado Department of Public Health and Environment and the Colorado Stormwater Council. Can you please confirm what you know about me and my job position? Describe your current role at CDOT (to be open about and transparent with bias.)

- If at any time I use a term or acronym that you are not familiar with please stop me for clarification.
- Can you provide a short biography for this report? (If they have not already provided).
- Would you like to get your biography from this interview or would you prefer to supply a written biography?
- Did you have time to review the TSS Policy Analysis Matrix?

- Did you have any questions about the Policy Analysis Matrix (the excel sheet) or the guidance document (the.pdf sheet)?
  Where the policy alternatives are effective in the stated goal of being "specific and measurable".

- Will you have time to fill out the Matrix?

- Would you like to use some of this interview time to add to the narrative section of your policy analysis matrix or would you prefer to fill this out on your own time?
  Note: please keep in mind that if I fill out the matrix based on our interview there could be transcription errors, are you okay with that?

- Did you find the TSS Policy Analysis Matrix a good or bad supplement to this interview process and exploration, why or why not?

- Are there any policies that you feel were not addressed in the Policy Analysis Matrix?

- Would you be willing to share your ideas regarding an alternative policy or the other category in the matrix?

- Can you tell me about your understanding on the use of Manufactured Treatment Devices (MTD) within your municipality?

- Can you please describe what equity means to you?
  Where do you find MTDs used most often?
  Are any of these locations in disproportionately impacted areas in your community? If yes, do you anticipate any equity concerns with the use of these devices?

- Can you discuss how you see the differences between a volumetric and a percent removal TSS standard?

- How does your program currently track the effectiveness of TSS removal rates from MTDs? Is that your preferred method?

- In your opinion is there another standard similar to water quality capture volume we should be looking at when it comes to MTDs?

- Are you familiar with the current New Jersey Department of Environmental Protection (NJDEP) or the Washington State Emerging Stormwater Treatment Technologies (better known as TAPE) testing protocols for manufactured treatment devices?
  Note: follow up questions based on answers

- Do you feel there is an issue with current permit requirements within Colorado MS4 permits when it comes to the pollution removal standard of 30mg/L?
  If so, can you tell me what challenges you or your community face?

- How are you currently accounting for the influent concentrations when providing specifications to manufacturers or contractors?

- How are you currently accounting for the particle size for the influent concentration of a manufactured treatment device?

- Can you share your current standard or policy guidance that your municipality or organization is utilizing to install manufactured treatment devices?

- Would you consider a policy change from a weight per volumetric mg/L standard to a percent removal standard to be of equivalent effluent quality and can you please tell me why or why not?

- For future studies on TSS/Pollutant removal standards would you recommend other resources or including specific individuals or organizations?
  Note: this question will involve divulging other interviewees. This is expected to remain transparent and ethical.

- If policy guidance or a crosswalk from volumetric to percent removal regarding MTDs was selected what organization would be in the best position to develop such guidance or crosswalks?
  Can you expand upon why you came to that decision?

- Are you familiar with the Stormwater Testing and Evaluation for Products and Practices (STEPP) program that is part of the National Municipal Stormwater Alliance?

- Do you feel like this organization can help unify testing protocols and MS4 permit standards nationwide?
  Do you find value in this system? Ask to expand.

- Are you familiar with the American Standards and Testing Methods (ASTM) E64 Committee on Stormwater Control Measures?

- Do you think this committee and standardizing the testing methods of manufactured treatment devices in a laboratory setting will change your mind regarding the Colorado Pollutant removal standard and if so in what way?

- What additional research do you think would be useful in ensuring MTDs are protecting or improving water quality?

- Are you comfortable with the term technocrat or elite and being identified as such for this study?
  Follow up the definition is a person who are leaders or experts (with technical knowledge) within a community.

- If you oversaw the pollutant removal standard at CDPHE what would be your proposed solution to allow manufactured treatment devices (or not allow) and meet established water quality standards and regulations?

- Is there anything you would like to add, take away or amend from this interview or the TSS Policy Analysis Matrix?

Targeted questions toward individuals:

Erin Powers, MS4 Program Manager for City of Colorado Springs

Erin you were selected for your MS4 engineering management as a phase-1 MS4 community.
Can you tell me issues dealing with the pollutant removal standard that might be unique to Colorado Springs or to a phase-1 community.
Should Colorado Springs or other phase-1 communities have a unique pollutant removal standard why or why not?

Carrie Gudorf, /Josh Martinez, Regulatory Programs Manager for Mesa County

Carrie/Josh, you were selected as the only Western Slope MS4 permittee representatives in this study, can you please tell me if there are any issues dealing with the pollutant removal standard that are unique to the West Slope?

Craig Fairbaugh, Regional Regulatory Manager for Contech Engineering Solutions

Craig, you were selected as the only manufacturer representative for this very focused study. Can you tell me about your perspective from the supply side that regulators don't seem to understand or can't see?
What would you like regulators to know about how you arrive at demonstrated performance of manufactured products?
Craig, regulatory goals and manufacturer private sector goals don't always align. What solutions do you see that could help both reach their end goal of protection and profit?

What incentives would be helpful or what obstacles could be removed that could help achieve these goals?

How does industry view the TSS requirements and what is the one thing that you could change to make better partnerships between industry and regulators?

Is there anything researchers should be telling regulators to do, that we might be missing?

Holly Piza, Research and Development Director for Mile High Flood District

Holly, during my research into this issue I found that many references to Mile High Flood District/Urban Drainage and Flood Control Volume-3 criteria manual references. Can you help me with how the district came to the 30mg/L standard for treatment in your own words?

Can you share the studies that guided the districts decision to rely on the volumetric or percent removal TSS standards?

Do you feel this is still a good standard why or why not?

Holly, who do you consider the primary audience of the MHFD Volume-3 Criteria Manual regarding water quality?

Holly, can you share your history developing guidance around the 30mg/L standard?

Holly, do you think Colorado has the research capacity to start a lab-based testing/verification center in Colorado?

Jake Moyer, Stormwater Administrator for City of Arvada

Jake, as the Colorado Stormwater Council Chair of the Post-Construction committee you were selected to represent most of the phase-2 MS4 Permitees.

Can you tell me what the greatest challenges and benefits of MTDs from have been for the:

1. Design-phase
2. Operation and maintenance perspective

3. The goal of protecting water quality

4 Selection of MTDs

In Arvada and Westminster as well as; during the short history of the Post-Construction committee and the combined comments of the Colorado Stormwater Council?

Juliana Archuleta, Stormwater Administrator for Adams County

Juliana, you were selected to be part of this study because of your tireless work to improve water quality for underserved populations and your bi-lingual outreach efforts; in addition, you are representing a county phase-2 MS4 perspective.

Juliana, do you see a link between the use of MTDs and in-equity?

If yes, listen carefully for follow up questions and expansion.

Can you tell me if there are any County specific issues that Cities or Transportation MS4s need to be aware of relating to the use of the pollutant removal standard or TSS requirements of the MS4 permit?

Seth Brown, Executive Director of National Municipal Stormwater Alliance

Seth, you were selected for this study as a national expert in TSS removal and research.

Can you tell me the difference between verification and certification?

Can you tell me what the national mood of verifying/certifying manufactured treatment devices before installation?

What role do you see the STEPP program fulfilling for Colorado?

Through the STEPP MTD verification program, what environmental benefits or impacts does the program consider when deciding what they will verify?

Do you think Colorado should have a testing lab specifically for Colorado or the Mountain West?

Is there anything at the national level that we are not seeing or accounting for in Colorado?

Is there anything research should be telling regulators to do, that we might be missing?

What do you hope the updates that are forthcoming on MTD will accomplish, what do you see as the goals?

Tyler Dell, Civil Engineer II for City of Longmont

Tyler, you were selected for this study because you represent a phase-2 city MS4 and your long years of research on this subject as the Program Manager/Researcher at the Colorado Stormwater Center at Colorado State University.

Tyler, do you think Colorado has the research capacity to start a lab-based testing/verification center in Colorado?

Tyler, can you tell me your view of Colorado based research on the use of the Pollutant Removal Standard or the TSS standard?

Can you describe to me in your own words the benefits and consequences of using manufactured treatment devices for water quality treatment?

Coming from research to the regulatory arena, has there been anything you feel MS4s are simply missing that research tells us we should be doing?

Tyler, can you share your thoughts and any discussions you had while at the Colorado Stormwater Center regarding testing MTDs in Colorado?

Jeremiah Unger
Graduate Student, School of Public Affairs
University of Colorado Denver

If you have any questions, please contact the primary researcher, Jeremiah Unger, at jeremiah.unger@state.co.us or (303) 513-3927.

Appendix G
Blank Policy Analysis Matrix

TSS Analysis Matrix	Cost	Water quality benefit	End user acceptability	Effectiveness	Equity	Summary & Recommendations
	Low = 1	Low = 1	Low = 1	Low = 1	Low = 1	Overall Quantitative Score
Status Quo, No Action Alternative	The criteria of cost effectiveness deal specifically with the success of a potential policy alternative and its direct relation to the financial cost of the policy. The more effective the policy alternative, and the lower the policy cost, the higher the policy will rate on the continuum. Please use this cell to add your comments regarding your score of cost as it relates to the Status Quo, No Action Alternative.	Determining how effective a standard or policy will be at protecting water quality. Please use this cell to add your comments regarding your score of water quality benefits as it relates to the Status Quo, No Action Alternative.	The acceptability of a policy by permittees that must rely on information to determine if a control measure is acceptable to meet MS4 permit requirements. Please use this cell to add your comments regarding your score of the end user acceptability (MS4 permittees) as it relates to the Status Quo, No Action Alternative.	A policy alternatives effectiveness is measured by whether it is successful at achieving the policy goals that were established. Please use this cell to add your comments regarding your score of the effectiveness of this policy as it relates to the Status Quo, No Action Alternative.	Equity establishes the variety of stakeholders given a specific policy. Equity determines whether the burden of a policy alternative is bore by a small segment of the population or a larger, more diverse segment. The more diverse and larger the distribution, the higher on the continuum the Equity score will rate. Equity between states is of primary concern. Please use this cell to add your comments regarding your score of the equity of this policy as it relates to the Status Quo, No Action Alternative.	Please use this area to add any notes and specify if this would be your recommended policy.
	Low = 1	Low = 1	Low = 1	Low = 1	Low = 1	Overall Quantitative Score
Crosswalk from mg/L to % removal	The criteria of cost effectiveness deal specifically with the success of a potential policy alternative and its direct relation to the financial cost of the policy. The more effective the policy alternative, and the lower the policy cost, the higher the policy will rate on the continuum. Please use this cell to add your comments regarding your score of cost as it relates to Creating a crosswalk from mg/L to % removal.	Determining how effective a standard or policy will be at protecting water quality. Please use this cell to add your comments regarding your score of water quality benefits as it relates to the creating a crosswalk from mg/L to % removal.	The acceptability of a policy by permittees that must rely on information to determine if a control measure is acceptable to meet MS4 permit requirements. Please use this cell to add your comments regarding your score of the end user acceptability (MS4 permittees) as it relates to the creating a crosswalk from mg/L to % removal.	A policy alternatives effectiveness is measured by whether it is successful at achieving the policy goals that were established. Please use this cell to add your comments regarding your score of the effectiveness of this policy as it relates to the creating a crosswalk from mg/L to % removal.	Equity establishes the variety of stakeholders given a specific policy. Equity determines whether the burden of a policy alternative is bore by a small segment of the population or a larger, more diverse segment. The more diverse and larger the distribution, the higher on the continuum the Equity score will rate. Equity between states is of primary concern. Please use this cell to add your comments regarding your score of the equity of this policy as it relates to the creating a crosswalk from mg/L to % removal.	Please use this area to add any notes and specify if this would be your recommended policy.
	Low = 1	Low = 1	Low = 1	Low = 1	Low = 1	Overall Quantitative Score
Limited MTD/Proprietary Technologies from STEPP list	The criteria of cost effectiveness deal specifically with the success of a potential policy alternative and its direct relation to the financial cost of the policy. The more effective the policy alternative, and the lower the policy cost, the higher the policy will rate on the continuum. Please use this cell to add your comments regarding your score of cost as it relates to creating a limited MTD/Proprietary technologies from the STEPP list.	Determining how effective a standard or policy will be at protecting water quality. Please use this cell to add your comments regarding your score of water quality benefits as it relates to creating a limited MTD/Proprietary technologies from the STEPP list.	The acceptability of a policy by permittees that must rely on information to determine if a control measure is acceptable to meet MS4 permit requirements. Please use this cell to add your comments regarding your score of the end user acceptability (MS4 permittees) as it relates to creating a limited MTD/Proprietary technologies from the STEPP list.	A policy alternatives effectiveness is measured by whether it is successful at achieving the policy goals that were established. Please use this cell to add your comments regarding your score of the effectiveness of this policy as it relates to creating a limited MTD/Proprietary technologies from the STEPP list.	Equity establishes the variety of stakeholders given a specific policy. Equity determines whether the burden of a policy alternative is bore by a small segment of the population or a larger, more diverse segment. The more diverse and larger the distribution, the higher on the continuum the Equity score will rate. Equity between states is of primary concern. Please use this cell to add your comments regarding your score of the equity of this policy as it relates to creating a limited MTD/Proprietary technologies from the STEPP list.	Please use this area to add any notes and specify if this would be your recommended policy.
	Low = 1	Low = 1	Low = 1	Low = 1	Low = 1	Overall Quantitative Score
Colorado policy guidance and interpretation of existing standard	The criteria of cost effectiveness deal specifically with the success of a potential policy alternative and its direct relation to the financial cost of the policy. The more effective the policy alternative, and the lower the policy cost, the higher the policy will rate on the continuum. Please use this cell to add your comments regarding your score of cost as it relates to creating a Colorado specific policy guidance and interpretation of the existing 30mg/L standard.	Determining how effective a standard or policy will be at protecting water quality. Please use this cell to add your comments regarding your score of water quality benefits as it relates to creating a Colorado specific policy guidance and interpretation of the existing 30mg/L standard.	The acceptability of a policy by permittees that must rely on information to determine if a control measure is acceptable to meet MS4 permit requirements. Please use this cell to add your comments regarding your score of the end user acceptability (MS4 permittees) as it relates to creating a Colorado specific policy guidance and interpretation of the existing 30mg/L standard.	A policy alternatives effectiveness is measured by whether it is successful at achieving the policy goals that were established. Please use this cell to add your comments regarding your score of the effectiveness of this policy as it relates to creating a Colorado specific policy guidance and interpretation of the existing 30mg/L standard.	Equity establishes the variety of stakeholders given a specific policy. Equity determines whether the burden of a policy alternative is bore by a small segment of the population or a larger, more diverse segment. The more diverse and larger the distribution, the higher on the continuum the Equity score will rate. Equity between states is of primary concern. Please use this cell to add your comments regarding your score of the equity of this policy as it relates to creating a Colorado specific policy guidance and interpretation of the existing 30mg/L standard.	Please use this area to add any notes and specify if this would be your recommended policy.
	Low = 1	Low = 1	Low = 1	Low = 1	Low = 1	Overall Quantitative Score
Adopt percent removal standards into Colorado MS4 permits	The criteria of cost effectiveness deal specifically with the success of a potential policy alternative and its direct relation to the financial cost of the policy. The more effective the policy alternative, and the lower the policy cost, the higher the policy will rate on the continuum. Please use this cell to add your comments regarding your score of cost as it relates to adopting a percent removal standard pollution removal standard in Colorado MS4 permits.	Determining how effective a standard or policy will be at protecting water quality. Please use this cell to add your comments regarding your score of water quality benefits as it relates to adopting a percent removal standard pollution removal standard in Colorado MS4 permits.	The acceptability of a policy by permittees that must rely on information to determine if a control measure is acceptable to meet MS4 permit requirements. Please use this cell to add your comments regarding your score of the end user acceptability (MS4 permittees) as it relates to adopting a percent removal standard pollution removal standard in Colorado MS4 permits.	A policy alternatives effectiveness is measured by whether it is successful at achieving the policy goals that were established. Please use this cell to add your comments regarding your score of the effectiveness of this policy as it relates to adopting a percent removal standard pollution removal standard in Colorado MS4 permits.	Equity establishes the variety of stakeholders given a specific policy. Equity determines whether the burden of a policy alternative is bore by a small segment of the population or a larger, more diverse segment. The more diverse and larger the distribution, the higher on the continuum the Equity score will rate. Equity between states is of primary concern. Please use this cell to add your comments regarding your score of the equity of this policy as it relates to adopting a percent removal standard pollution removal standard in Colorado MS4 permits.	Please use this area to add any notes and specify if this would be your recommended policy.
	Low = 1	Low = 1	Low = 1	Low = 1	Low = 1	Overall Quantitative Score
Restricted use of MTD/Proprietary Technologies	The criteria of cost effectiveness deal specifically with the success of a potential policy alternative and its direct relation to the financial cost of the policy. The more effective the policy alternative, and the lower the policy cost, the higher the policy will rate on the continuum. Please use this cell to add your comments regarding your score of cost as it relates to restricting or eliminating the use of MTD/Proprietary technologies for pollutant removal standards in Colorado.	Determining how effective a standard or policy will be at protecting water quality. Please use this cell to add your comments regarding your score of water quality benefits as it relates to restricting or eliminating the use of MTD/Proprietary technologies for pollutant removal standards in Colorado.	The acceptability of a policy by permittees that must rely on information to determine if a control measure is acceptable to meet MS4 permit requirements. Please use this cell to add your comments regarding your score of the end user acceptability (MS4 permittees) as it relates to restricting or eliminating the use of MTD/Proprietary technologies for pollutant removal standards in Colorado.	A policy alternatives effectiveness is measured by whether it is successful at achieving the policy goals that were established. Please use this cell to add your comments regarding your score of the effectiveness of this policy as it relates to restricting or eliminating the use of MTD/Proprietary technologies for pollutant removal standards in Colorado.	Equity establishes the variety of stakeholders given a specific policy. Equity determines whether the burden of a policy alternative is bore by a small segment of the population or a larger, more diverse segment. The more diverse and larger the distribution, the higher on the continuum the Equity score will rate. Equity between states is of primary concern. Please use this cell to add your comments regarding your score of the equity of this policy as it relates to restricting or eliminating the use of MTD/Proprietary technologies for pollutant removal standards in Colorado.	Please use this area to add any notes and specify if this would be your recommended policy.
	Low = 1	Low = 1	Low = 1	Low = 1	Low = 1	Overall Quantitative Score
Other options	The criteria of cost effectiveness deal specifically with the success of a potential policy alternative and its direct relation to the financial cost of the policy. The more effective the policy alternative, and the lower the policy cost, the higher the policy will rate on the continuum. Please use this cell to add your comments regarding your score of cost as it relates to your other policy idea cost.	The criteria of cost effectiveness deals specifically with the success of a potential policy alternative and its direct relation to the financial cost of the policy. The more effective the policy alternative given a lower cost will rate higher on the continuum. Please use this cell to add your comments regarding your score of water quality benefits as it relates to your other policy idea.	The acceptability of a policy by permittees that must rely on information to determine if a control measure is acceptable to meet MS4 permit requirements. Please use this cell to add your comments regarding your score of end user acceptability as it relates to your other policy idea.	A policy alternatives effectiveness is measured by whether it is successful at achieving the policy goals that were established. Please use this cell to add your comments regarding your score of the effectiveness of this policy as it relates to your other policy idea.	Equity establishes the variety of stakeholders given a specific policy. Equity determines whether the burden of a policy alternative is bore by a small segment of the population or a larger, more diverse segment. The more diverse and larger the distribution, the higher on the continuum the Equity score will rate. Equity between states is of primary concern. Please use this cell to add your comments regarding your score of the equity of this policy as it relates to your other policy idea.	Please use this area to add any notes and specify if this would be your recommended policy.

Appendix H

Summary Table Policy Analysis Matrix

TSS Analysis Matrix	Cost		Water quality benefit		End user acceptability		Effectiveness		Equity		Summary & Recommendations	Overall Quantitative Score
Status Quo, No Action Alternative	Common Theme	2.88	Common Theme	2.75	Common Theme	1.88	Common Theme	2.13	Common Theme	1.88	Overall Quantitative Score	11.5
	The average score indicates a low/moderate to moderate rating for Cost of the No Action Alternative. Notable assumption: The main cost here is in staff time for MS4 personnel to try and figure out how to implement the regulations and design engineer time to see how to demonstrate design standard requirements.		The average score indicates a low/moderate to moderate rating for water quality benefit however; a few SME did indicate since this standard does not allow hydrodynamic seperators and only filtration systems this is highly rated category for that reason.		The average score indicates a low to low/moderate rating for end user acceptability "it's unacceptable to put the onerous on the MS4 to grapple with ambiguous standards without providing the necessary tools to properly evaluate if this is in fact compliant with the standard." A consensus shared among many for MS4 end user acceptability.		The average score indicates a low/moderate to moderate rating for effectiveness. A few participants (particularly those with Colorado MS4 permit responsibility shared comments similar to, not having an accepted industry standard and alternatives will result in poor water quality and reduced effectiveness.		The average score indicates a low to low/moderate rating for equity. A common theme was in-equity the source of in-euity seemed to be all over the place including: In-equity among states, MS4s, between state-reulators and local jurisdictions and the burden carried by manufacturers and developers.		This policy has the second lowest rating only above the Restricted use of MTD/Proprietary Technologies policy alternative. This indicates that the current status quo is not a good option and action in the form of another policy option. This is not a recommended policy solution.	
Crosswalk from mg/L to % removal	Common Theme	2.75	Common Theme	2.00	Common Theme	3.63	Common Theme	2.50	Common Theme	2.25	Overall Quantitative Score	16.125
	The average score indicates a low/moderate to moderate rating for Cost of a cross-walk alternative. A common theme was the cost to MS4s would be relatively minor in my opinion, but the cost to contractors could increase because they need to prove their MTD meets one or both standards. The high cost of developing such a tool.		The average score indicates a moderate rating for water quality benefit the comments were uniform in that no one saw increased water quality benefit over the current standard.		The average score indicates a moderate-to-moderate/high rating for end user acceptability of a crosswalk. Most participants seemed to think this would be more accepted by MS4 with the caviat that guidance and training was provided.		The average score indicates a moderate to moderate-high rating for effectiveness of a crosswalk. Most partipants that provided comment shared a common theme that this could help with the effectiveness of this policy alternative beyond the status quo however; were skeptical of the effectiveness compared to other policy alternatives beyond the no action and null alternatives.		The average score indicates a moderate moderate/high rating for equity of a crosswalk. It could help provide clarity and I don't think it is at the expense of any one group. Helps reduce the burden of all parties involved.		This policy has the lowest rank of the policy alternatives that are not the no action or null alternatives. The primary issue identified in the matrix and during interviews is the lack of d=actifin or how this policy alternative would be ultimately implemented and interpreted. This alternative did not have a recommended or common engineering agency, consultant or university identified to create such a cross-walk. This is not a recommended policy solution.	
Limited MTD/Proprietary Technologies from STEPP list	Common Theme	2.75	Common Theme	3.63	Common Theme	4.13	Common Theme	4.13	Common Theme	3.50	Overall Quantitative Score	18.125
	The average score indicates a low/moderate to moderate rating for Cost of a limited STEPP list alternative. While this is the recommended alternative this cost is the lowest rated field on this recommended alternative. This could be explained by a perception of a high cost of entry. Also considered is the on-going cost of maintaining such a list beared by manufacturers and MS4s to maintain such a list.		The average score indicates a moderate to moderate/high rating for the water quality benefit of a STEPP list. Despite having less freedom of choice in MTDs, at least we would know they were thoroughly reviewed and would in fact be meeting the standard.		The end user acceptability of the STEPP list is one of the highest ranked fields of within the matrix. Summarized by this comment, MS4s and developments would be very likely to use the practice as it would be very easy to use and likely effective		The effectiveness of the STEPP list is one of the highest ranked fields of within the matrix. Permittees would be able to more confidently varify and ensure that a proposed device is meeting the water quality requirements.		The average score indicates a moderate moderate/high rating for equity the STEPP list. While this was the recommended alternative the equity component was ranked as the second highes behind interpretation of existing guidance. A common theme of this alternative was expressed this way would encourage transparent and independent review/approval process.		This policy has the highest rank of the policy alternatives within the TSS policy analysis matrix. A nation-wide approval process would be ideal. This will take time and money. Municipalities do not have the expertise needed to make these decision. Effectiveness of the systems can be tested for different weather conditions, soil types and typical land uses. This should be a more clear, measureable and fair system for all underground manufacturers. This is the recommended policy solution based on Quantitative scoring.	
Colorado policy guidance and interpretation of existing standard	Common Theme	2.13	Common Theme	2.50	Common Theme	2.50	Common Theme	3.38	Common Theme	2.75	Overall Quantitative Score	17.25
	The average score indicates a moderate to moderate/high rating for the cost of a Colorado policy guidance. Policy guidance and interpretation of existing standard would be similar to allowing STEPP/TAPE/NJDEP devices. It would require a small amount of resources to create this guidance. MHFD draft manual and Denver policy can provide precedence on this policy guidance, so resources needed are low.		The average score indicates a moderate to moderate/high rating of the water quality benefit for the Colorado policy guidance alternative. Overall most participants did not see a loss nor a gain in water quality benefit for this option.		The average score indicates a moderate to moderate/high rating of the end user acceptability of the Colorado policy guidance alternative. Summarized by this comment, this would help a lot of MS4s feel more comfortable if additional guidance was provided by State of Colorado. End user acceptability would improve.		The average score indicates a moderate to moderate/high rating of the effectiveness of the Colorado policy guidance alternative.		The average score indicates a moderate to moderate/high rating for equity of the Colorado policy guidance alternative. CDPHE could provide an equitable solution as there would be direct input from CDPHE on exactly which practices meet the pollutant removal standard. Depending on if the policy went beyond just the pollutant removal standard though, there could still be inequity in how MTDs are evaluated as compared to non-proprietary SCMs. For example - if filtration MTDs are required for the pollutant removal standard, it is inequitable if sand filters and conventional biofilters still use the WQCV standard (which is based on sedimentation and a drain down time).		The policy alternative of creating a policy guidance document regarding the use of the existing 30mg/L standard was not rank ed the highest or the lowest. A common theme among all participants is the lack of understanding of how this policy would help the current situation however; The did not see a significant burden to cost or water quality benefits. A few participants hailed this as a good option and references the current draft guidance in Volume-3, chapter 4, section T-11 of the Urban Drainage Storm Drainage Criteria Manual. That this would be meet such guidance.	
Adopt percent removal standards into Colorado MS4 permits	Common Theme	2.75	Common Theme	3.13	Common Theme	2.63	Common Theme	3.75	Common Theme	3.38	Overall Quantitative Score	17.625
	The average score for this policy analysis alternative is the highest among all policy options for cost within the Matrix. This scenario would have the best cost as it is the data that MTDs currently have. It doesn't necessarily require a process to ensure good facilities so the overall quality of facilities would allow for the cheapest MTDs that claim a percent removal to be available.		The average score indicates a moderate to moderate/high rating of the water quality benefit for theadoption of the 80% TSS policy alternative. This is the best option for water quality. Standards that are easily measureable and understood by a large portion of the nation.		The average score indicates a moderate to moderate/high rating of the end user acceptability of the 80% TSS policy alternative. A majority of participants with MS4 permit responsibility ranked the end user acceptability as moderate/high-or high. This is telling if only MS4 permittees are looked at. As they are generally the end users of MTDs.		The average score for this policy analysis alternative is the highest among all policy options for effectiveness within the Matrix. This would be relatively effective. The only concern would be that the practices would not be very good, but the standard would be clear and easy to show.		The average score indicates a moderate to moderate/high rating for equity of the 80% TSS policy alternative. This policy is more fair for every player within the Colorado MS4 permitting system.		This policy has the second highest rank of the policy alternative within the TSS policy analysis matrix. A policy change at CDPHE within the WQCD to an 80% TSS removal rate will reduce ambiguity of permit compliance when compared to other verification programs used across the nation. This is a recommended policy solution based on Quantitative scoring.	
Restricted use of MTD/Proprietary Technologies	Common Theme	1.75	Common Theme	2.75	Common Theme	2.00	Common Theme	2.63	Common Theme	1.13	Overall Quantitative Score	10.25
	The average score indicates a low to moderate/low rating of the cost for the null alternative. No participants had high ratings for this null policy option.		The average score indicates a moderate to moderate/low rating of the water quality benefit for the null alternative. No participants had high ratings for this null policy option.		The average score indicates a moderate/low rating of the end user acceptability for the null alternative. No participants had high ratings for this null policy option.		The average score indicates a moderate to moderate/low rating of the effectiveness of the null alternative. No participants had high ratings for this null policy option.		The average score indicates a low to moderate/low rating of the equity of the null alternative. Equity of the null alternative was the lowest rated of all categories of this Matrix.		A complete restriction of MTDs is the lowest rated policy. This indicates the need for these devices to fulfill needs within the MS4 community. This is not a recommended policy solution.	
Other options	Subject matter experts were given this section within the matrix to propose a policy solution that was not presented as an alternative. Subject matter experts did not have the opportunity to review or rate other options policy alternatives from other participant. Most alternatives provided are a hybrid of other policy options or slight changes to existing protocols. Only four subject matter experts of eight that participated added an alternative policy, please see a summary of those proposed options below:											
	I believe my preferred option would be standard that allows for either percent removal standard, however it also includes an approved certification & verification program that includes evaluating percent removal, overall effluent standards, and testing of re-suspension of sediment. In my ideal world this would be a two-phase approach where, for the first phase, a technology can receive certification based on peer review study conducted by the manufacturer and verified by a program like TAPE or NJCAT. Once a technology receives this first phase it is eligible for field installation with a condition that a certain number of rainfall events must be sampled (i.e. provide 10 influent/effluent samples within 36 months of final build out), and annual sediment accumulation measured for 3 years. The MTD would, after a certain number of field locations were verified to perform in a manner consistent with water quality goals, would receive final verification and would not longer require additional sampling and could just be installed/accepted. If field verification after a set number of applications does not show to function then the original certification can be withdrawn, however it should NOT require the practices to be removed. We would accept these as the cost of innovation and improvement.											
	Add flexibility to the arbitrary and stringent 30 mg/l TSS adopted, but find a way to match them to an industry testing protocol. Maybe establish a simple sampling plan that manufacturer's can perform in Colorado to show compliance.											
	Rely on New Jersey Department of Environmental Protection laboratory testing protocol for HDSs (NJDEP 2021) International BMP summaries.											
	I strongly recommend a unit operations approach that incorporates both performance verification and a prioritization of base design standards. In a unit operations approach, policy guidance would be provided that filtration is required to meet the 30 mg/L standard, and TAPE GULD Basic treatment systems are sufficient. The runoff reduction standard would be required to be evaluated first. If infeasible, then practitioners would move on to filtration and the pollutant removal standard. If filtration is infeasible, then the WQCV standard could be used for sedimentation type SCMs (ponds, EDBs, and HDS). This would require additional policy guidance for the WQCV standard as well, but would provide the best water quality outcomes for each site. This is similar to the MHFD Figure 4-1, but that figure is not policy, rather design guidance. Many permits and design manuals require a unit operations approach and it is the most technically sound policy to support water quality for all stakeholders.											

Appendix I

Typical Hydrodynamic Separator (HDS) Unit

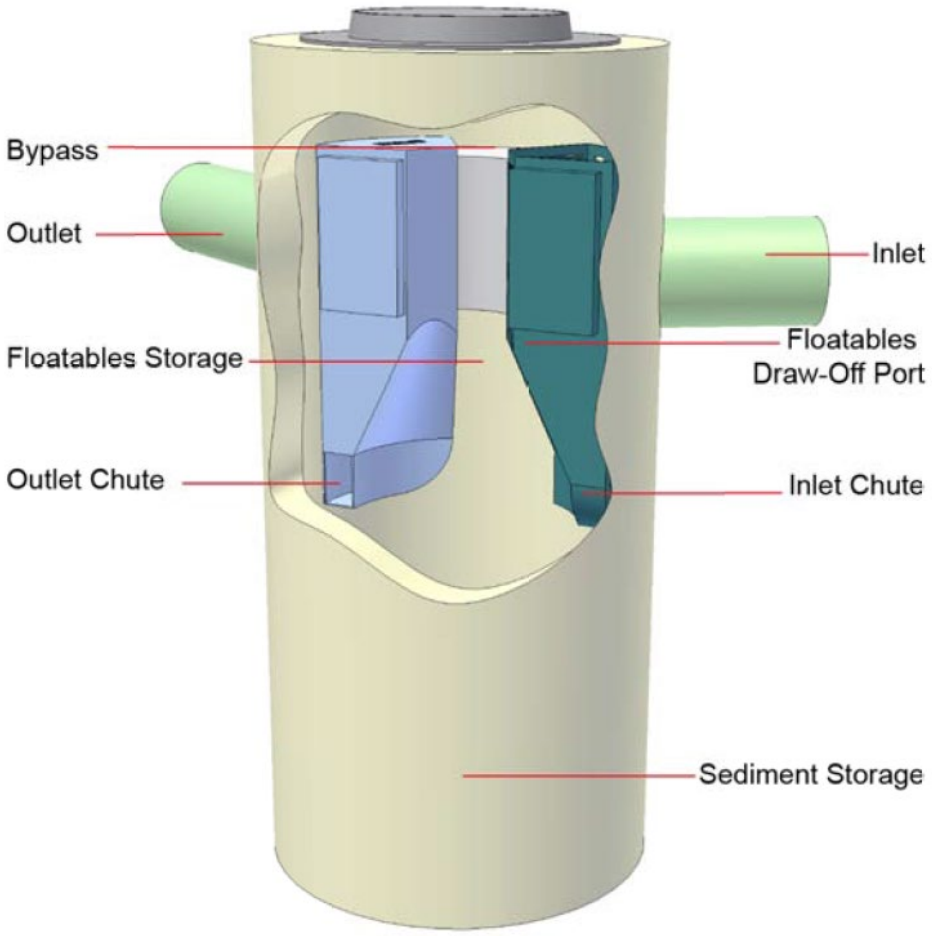

Figure 1. First Defense™ Hydrodynamic Separator (HDS)

Appendix J

Solids Size Classification Diagram

Exhibit 4-6. Solids Size Classification Diagram
(Source: Roesner et al. 2007)

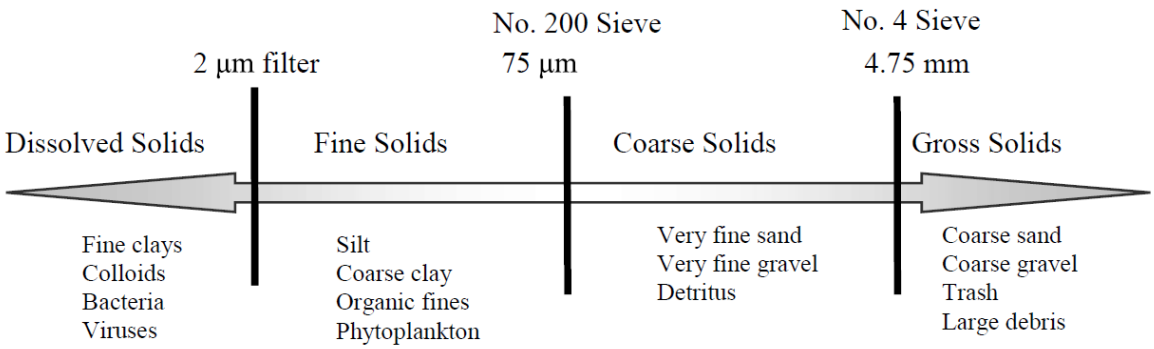

Figure 2, (Urban Stormwater BMP Performance, 2009)

Appendix K

Equations for Total Suspended Solids Calculations

$$\text{TSS test results, mg/L} = \left(\frac{\text{Net dry weight, mg}}{\text{Sample volume, mL}}\right) \text{X } 1000 \text{ mL/L}$$

$$\text{TSS removal efficiency, \%} = \left(\frac{\text{Influent TSS} - \text{Effluent TSS}}{\text{Influent TSS}}\right) \times 100\%$$

Figure 3, (State of Indiana, 2015)