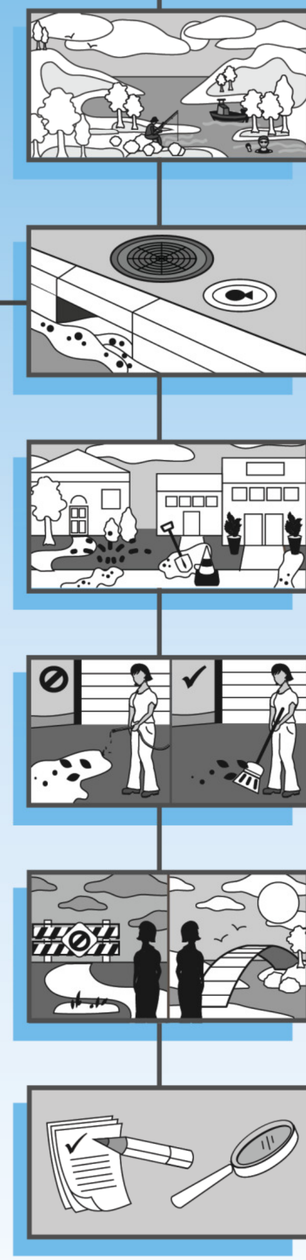
A Strategic Approach to

Planning for and Assessing the Effectiveness of Stormwater Programs



CALIFORNIA STORMWATER QUALITY ASSOCIATION

February 2015

This page intentionally left blank

A Strategic Approach to Planning for and Assessing the Effectiveness of Stormwater Programs

California Stormwater Quality Association

February 2015

This page intentionally left blank

Copyright Statement

Disclaimer

This page intentionally left blank

Acknowledgements

Contributing Authors

Jon Van Rhyn, County of San Diego Watershed Protection Program

Karen Ashby, Larry Walker Associates, Inc.

David Pohl, ESA PWA

Brian Currier, California State University Sacramento Office of Water Programs

Scott Taylor, RBF Consulting

Betsy Elzufon, Larry Walker Associates, Inc.

Rachel Warren, Larry Walker Associates, Inc.

Geoff Brosseau, California Stormwater Quality Association

Subcommittee Members

Arne Anselm, Ventura Countywide Stormwater Quality Management Program

Lisa Austin, Geosyntec Consultants

Chris Crompton, County of Orange Resources and Development Management Department

Bryn Evans, Dudek

Cathleen Garnand, County of Santa Barbara Public Works

Aracely Lasso, Los Angeles County Department of Public Works

Lou Leet, City of American Canyon

Daniel Rourke, Fresno Metropolitan Flood Control District

Dominic Roques, Central Coast Regional Water Quality Control Board

Gerald Takayesu, City and County of Honolulu Department of Environmental Services

Graphics Support

Carla Mardian

This page intentionally left blank

Table of Contents

List of Tables

List of Figures

Executive Summary

ES.1. Introduction (Section 1)

Municipal Separate Storm Sewer System stormwater programs (MS4 programs) are inherently complex for a variety of reasons.

- They typically address a number of major sources within their area of jurisdiction (construction, development, residential areas, municipal operations, and industrial and commercial facilities) and have to administer the program to tens of thousands to millions of individuals, sites and/or sources.
- Due to the geographic area that the MS4 program covers, the vast number of potential pollutants, and the volumes of flows that must be addressed, the programs tend to predominately focus on the use of source control best management practices (BMPs). While treatment controls are an important part of the MS4 program, managers often find themselves seeking to bring about the broad-scale implementation of many small controls by third parties.
- The flows in an MS4 are transported via both manmade and natural, open systems. The ability to measure, modify, or control MS4 discharges is complicated by the co-mingling of both anthropogenic and natural flows and pollutants within these systems. In addition, MS4s are often impacted by a number of non-point sources such as groundwater seepage, wind-blown and directly-deposited materials, and aerial deposition.

Despite these and other challenges, stormwater program managers find themselves facing increasing pressure to demonstrate the effectiveness of their programs, often with little guidance on how to do so. Without the specific knowledge or the tools needed to do so, stormwater managers can be faced with a perception that their programs are inadequate or failing.

Effectiveness assessment consists of the methods and activities that managers use to evaluate how well their programs are working and to identify modifications necessary to improve results.

The primary purpose of this Guidance Document is to establish specific "how to" guidance with examples for managers in planning and assessing their MS4 programs. It approaches effectiveness assessment as an integral part of a comprehensive strategic planning process. It is designed for use by MS4 program managers involved in developing and implementing all aspects of stormwater programs, but it should also be useful to a variety of dischargers regulated under other stormwater permits and programs (e.g., construction and industrial), as well as other environmental managers with a need for guidance on management and assessment principles.

Executive Summary

A structured approach to planning and assessing stormwater programs can help managers ensure that their programs are properly targeted, determine whether intended results are being efficiently and cost-effectively achieved, relate implementation results to conditions in urban runoff and receiving waters, and, ultimately, help guide managers toward implementation strategies with the greatest opportunity for long-term success.

Table ES.1 provides an overview of the organization of this Guidance Document, and briefly describes the purpose of each section.

Table ES.1: Organization of the Guidance Document

1.0	**Introduction and Purpose**	Provides background on the development and use of effectiveness assessment methods and their important to stormwater program managers.
2.0	**General Concepts and Principles**	Introduces the main components of the program planning and assessment processes, describes their use, and defines standardized concepts and terminology used throughout the Guidance Document.
3.0	**Introduction to Strategic Planning for Stormwater Management Programs**	Describes a stepwise process for developing a Comprehensive Program Planning Strategy, including problem characterization, goal setting, selection of control strategies and program activities, and the establishment of methods and metrics to assess effectiveness.
4.0	**Source and Impact Strategies**	Applies the strategic planning process introduced in Section 3.0 to the development of Source and Impact Strategies.
5.0	**Target Audience Strategies**	Applies the strategic planning process introduced in Section 3.0 to the development of Target Audience Strategies.
6.0	**Program Implementation Strategies**	Applies the strategic planning process introduced in Section 3.0 to the development of Program Implementation Strategies.
7.0	**Assessment Tools and Strategies**	Applies the strategic planning process introduced in Section 3.0 to the identification of tools and strategies for conducting assessments.
8.0	**Interpretation and Use of Results**	Provides examples of effectiveness assessments that have been conducted by stormwater programs throughout the state.
Att. A	**Glossary of Acronyms and Terms**	Defines key acronyms and terms used throughout the document.
Att. B	**Source Profiles**	Provides additional background information on the following source categories: construction, industrial, commercial, municipal operations, and planning and land development.
Att. C	**Constituent Profiles**	Provides additional background information on the following common constituents: bacteria, sediment, nutrients, mercury, pesticides, and trash.

ES.2. Stormwater Management Approach (Section 2.0)

This section describes the primary components of a comprehensive Stormwater Management Approach. Within these components, six types of Outcome Levels are introduced. Outcomes are the backbone of the strategic planning and assessment processed described in this document. They provide the structure and measurability needed to evaluate and improve Stormwater Management Programs over time.

For the purposes of this document, stormwater management consists of three primary components:

- **Sources and Impacts** - the physical component of the management approach, i.e., it deals with the generation, transport, and fate of pollutants and flows from the urban environment (Outcome Levels 6, 5, and 4).
- **Target Audiences** - the behavioral portion of the management approach i.e., the actions of target audiences and the factors that influence them (Outcome Levels 3 and 2).
- **Stormwater Management Programs** - the various activities that are conducted within a program (Outcome Level 1).

Outcomes are measurable endpoints associated with programs, people, and physical systems. They are the building blocks of the management approach described in this document.

Starting with Level 1 (Program Activities) and moving sequentially toward Level 6 (Receiving Water Conditions), they represent a general progression of conditions that are assumed to be related in a sequence of causal relationships. While it may initially seem counterintuitive, managers will normally address the six Outcome Levels in "reverse order" (from Level 6 to Level 1) during planning and assessment (**Figure ES.1**). The reason for this is that, in practice, they must work backwards from measured or observed effects to try and establish their causes. **Figure ES.2** illustrates the general relationship of the three stormwater management program components listed above and the six different Outcome Levels associated with them.

Figure ES.1: The "Counterintuitive" Order of Planning and Assessment Activities

Executive Summary

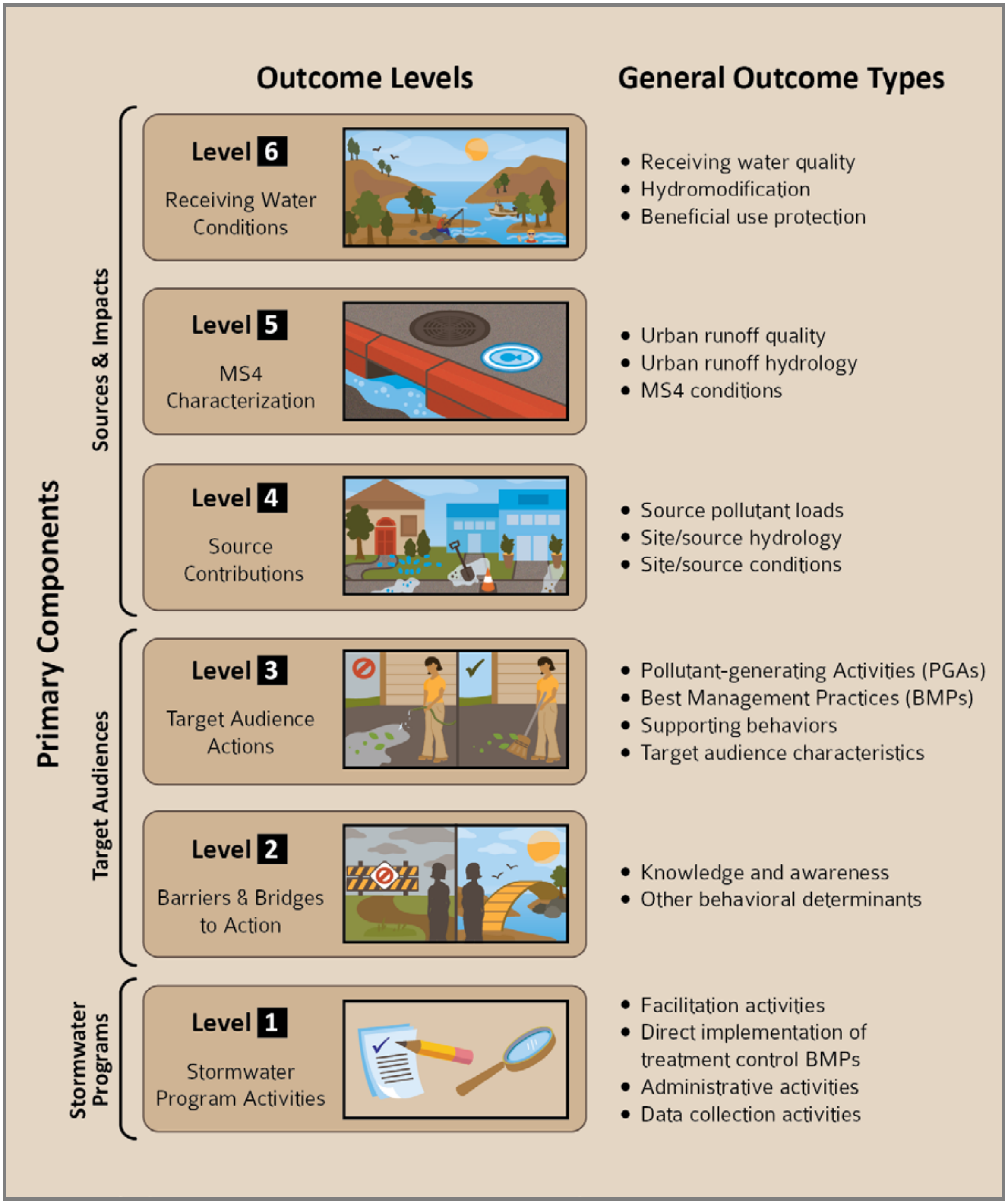


Figure ES.2: General Stormwater Management Model

This section walks the reader through each of the six individual Outcome Levels (shown in Figure ES.2) within the context of each of the primary components (**Sources and Impacts, Target Audiences,** and **Stormwater Management Programs**). This assists in understanding each Outcome Level both individually and in relation to the others that are influenced by it. This is critical in order for the Program to be measurable and effective in the long term.

ES.3. Introduction to Strategic Planning for Stormwater Management Programs (Section 3.0)

This section applies the concepts and principles described in Section 2 to the development of a **Stormwater Strategic Plan** that will guide the development and implementation of specific stormwater management plans and programs, and establish a basis for evaluating and updating them. Strategic planning for stormwater managers is best thought of as "strategic problem solving." Managers will identify and prioritize the problems to be addressed by their programs and develop strategies for resolving them. The general planning process described in this section provides the basis for the more detailed guidance described in the remainder of the document.

A **Stormwater Strategic Plan** (**SSP**) helps guide the development and modification of a **Stormwater Management Plan** (**SWMP**). The purpose of the SSP is to systematically explore and define the strategies that will be considered and incorporated as a part of a SWMP, and to suggest how program managers might choose some options over others. In some cases, a SSP may be equivalent to, or part of, a SWMP. In others, it may constitute a separate planning document that informs SWMP development. The SSP will also meet the requirements in the Small MS4 permit for the development of a Program Effectiveness Assessment and Improvement Plan (PEAIP).

Development of a Stormwater Strategic Plan is divided into three distinct stages.

- **Planning Preparation (Stage 1) -** managers establish the basic organizational framework necessary to compartmentalize and make sense of the detailed planning tasks that follow (Section 3.2). This consists of the following steps:
  - Establishing the Strategic Plan Framework
  - Compiling Data and Information
- During **Strategic Planning (Stage 2)**, managers identify and prioritize problems to be addressed, identify specific goals for resolving them, and identify program activities needed to drive and evaluate these changes (Section 3.3).
  - **Figure ES.3** illustrates the core elements of a comprehensive strategic planning process for stormwater management programs.
    - In **Step A**, existing conditions (or outcomes) are evaluated, first very broadly and then in detail, to determine which of them constitute problems potentially requiring a management response. The tasks involved in completing this step are illustrated in **Figure ES.4**.

- In **Step B** priority problem conditions are reviewed to determine the types of changes that will be sought and to establish timelines for achieving them. The tasks involved in completing this step are illustrated in **Figure ES.5**.
- **Step C** identifies and documents knowledge and data deficits. While this is shown as a discrete step in Figure ES.3, it's actually an integral part of the entire planning process. The tasks involved in completing this step are illustrated in **Figure ES.6**.

o **Figure ES.7** lays out the entire process for all Stormwater Management Program Components from beginning to end and identifies the sections of this document in which individual planning elements are addressed in greater detail.

- **Strategic Plan Completion (Stage 3)** provides a roadmap to guide program implementation and evaluation (Section 3.4). All Stormwater Strategic Plans will be different depending on their unique needs and circumstances, but each of the following elements should be considered for potential inclusion:
  - Source and Impact Strategies
  - Target Audience Strategies
  - Program Implementation Strategies
  - Assessment Tools and Strategies

Completing this comprehensive process will often require that a wide range of data and information be considered, sometimes beyond explicit regulatory requirements. The purpose of this process is not to create additional requirements, rather it is designed to help managers more effectively and efficiently meet existing ones.

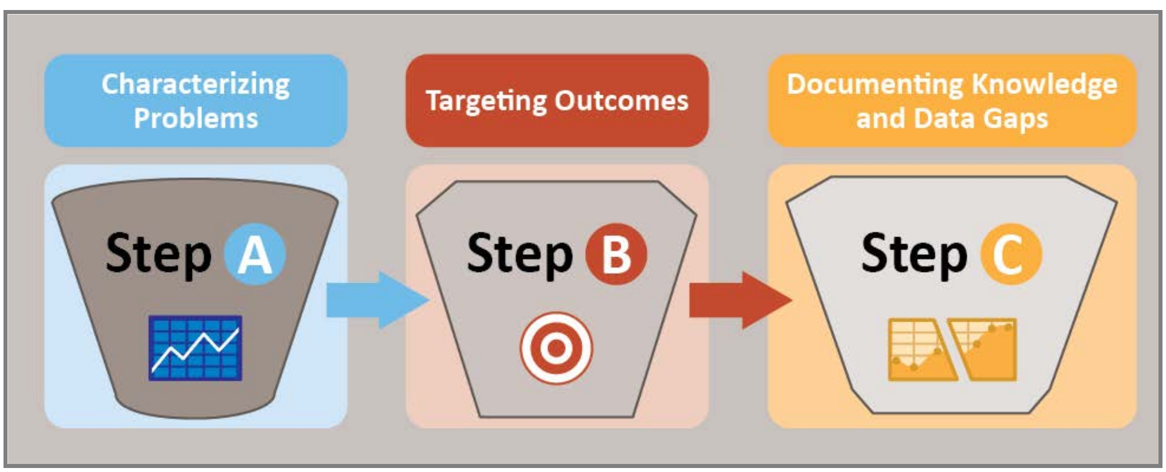


Figure ES.3: Core Strategic Planning Steps (applies to Outcome Levels 2 through 6)

Executive Summary

Step A Characterizing Problems

During characterization, managers explore what is known about existing conditions at all Outcome Levels, determine which of them constitute problems, and develop priorities for the changes to be sought through program implementation. This work is divided into three tasks as shown and described below.

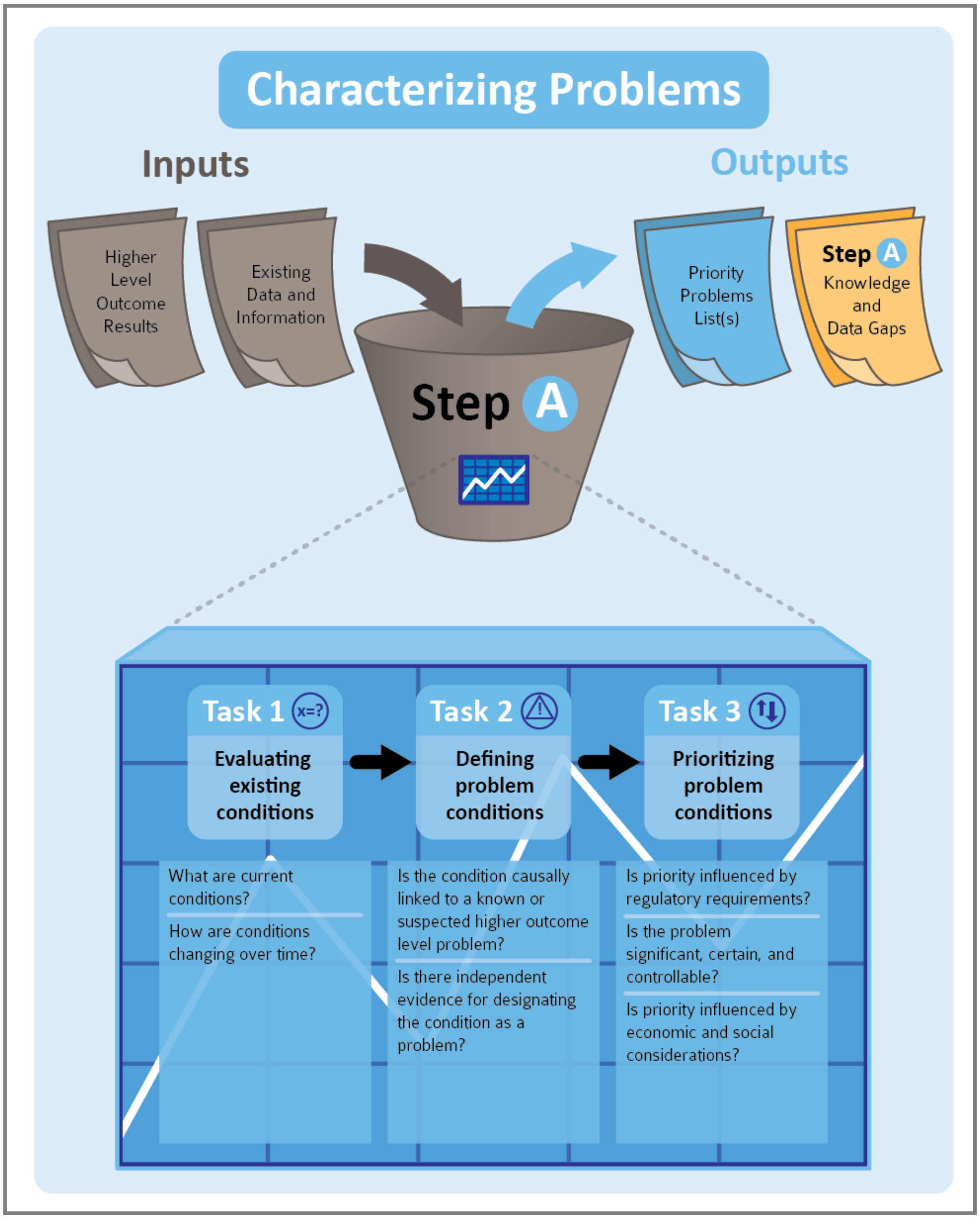


Figure ES.4: General Process for Characterizing Problems

Step B Targeting Outcomes

Targeted outcomes will define what a control strategy is designed to achieve, and in turn how specific actions can be directed to facilitate these changes.

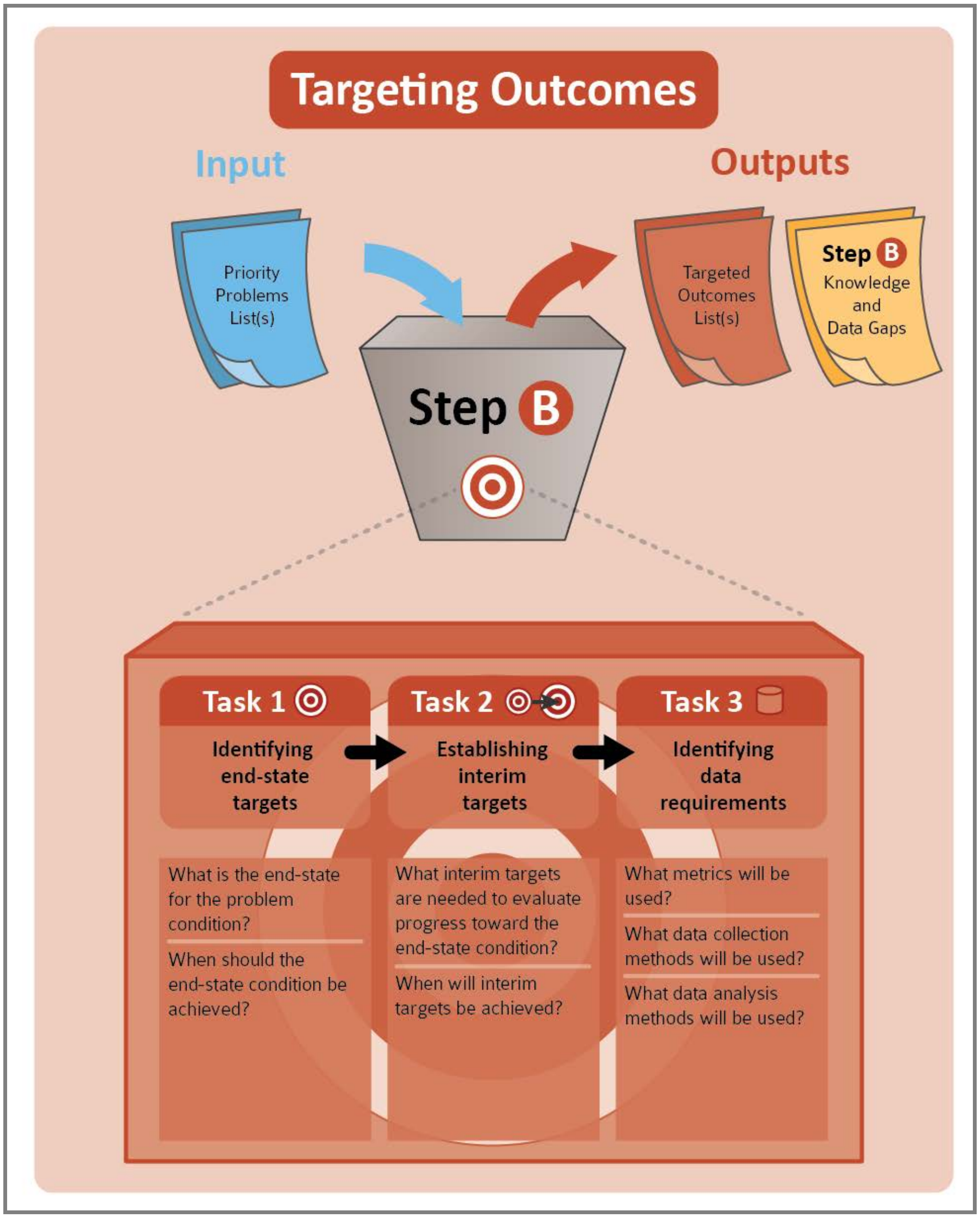
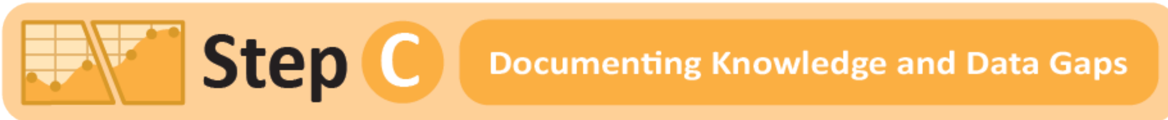


Figure ES.5: General Process for Targeting Outcomes



Knowledge and data gaps should be documented throughout the planning process, and strategies developed for addressing critical gaps through targeted data gathering initiatives.

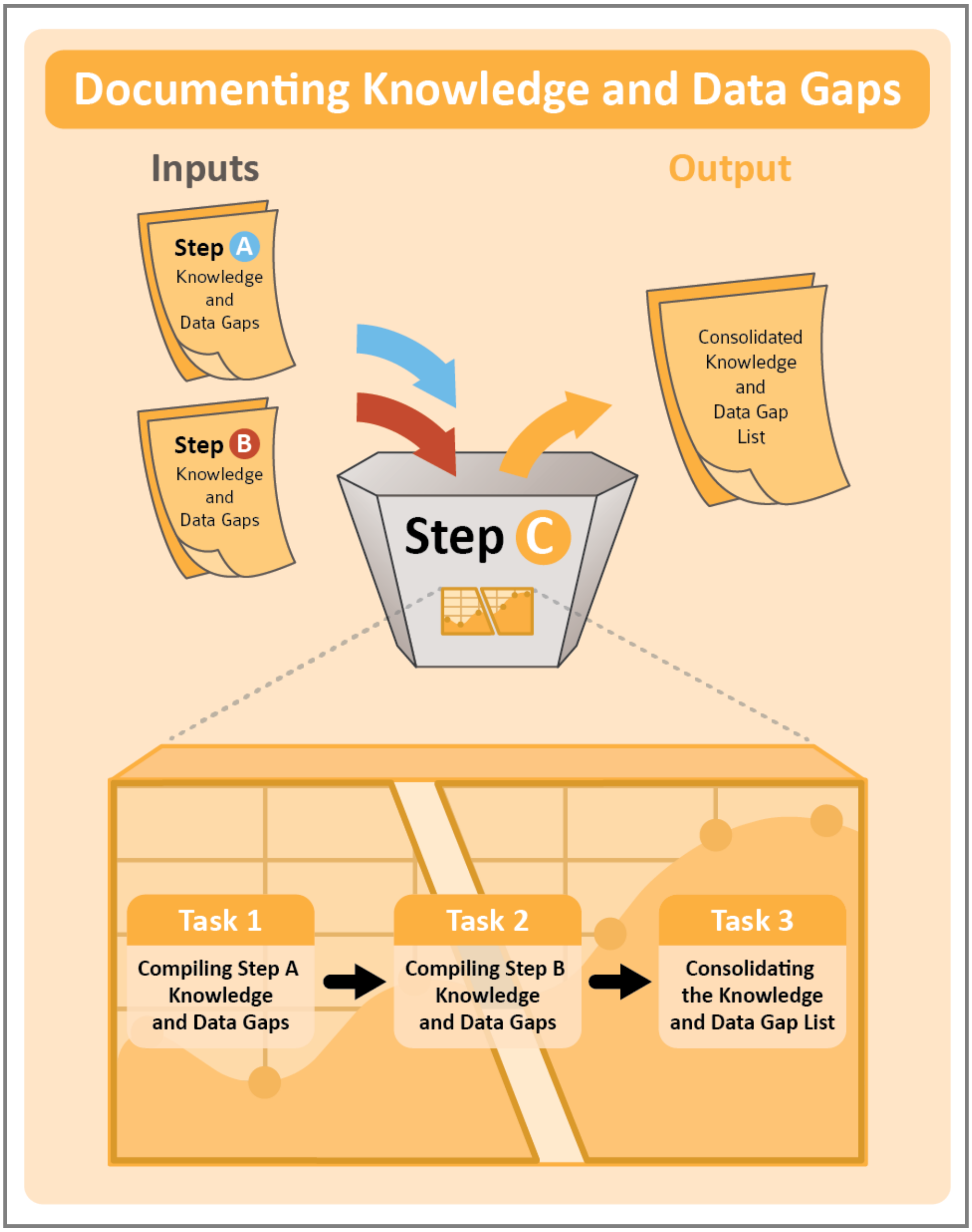


Figure ES.6: General Process for Consolidating Knowledge and Data Gaps (Step C)

Executive Summary

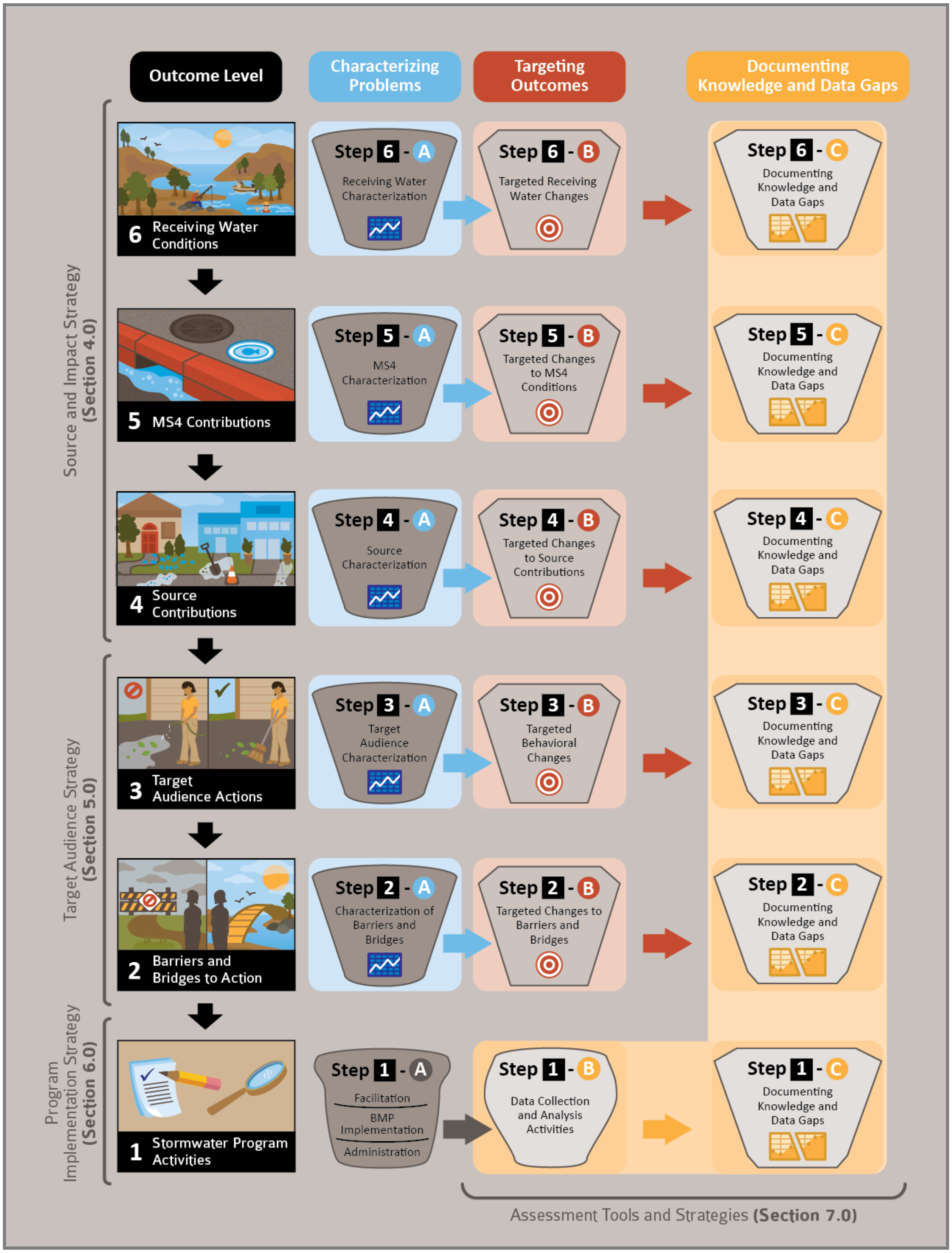
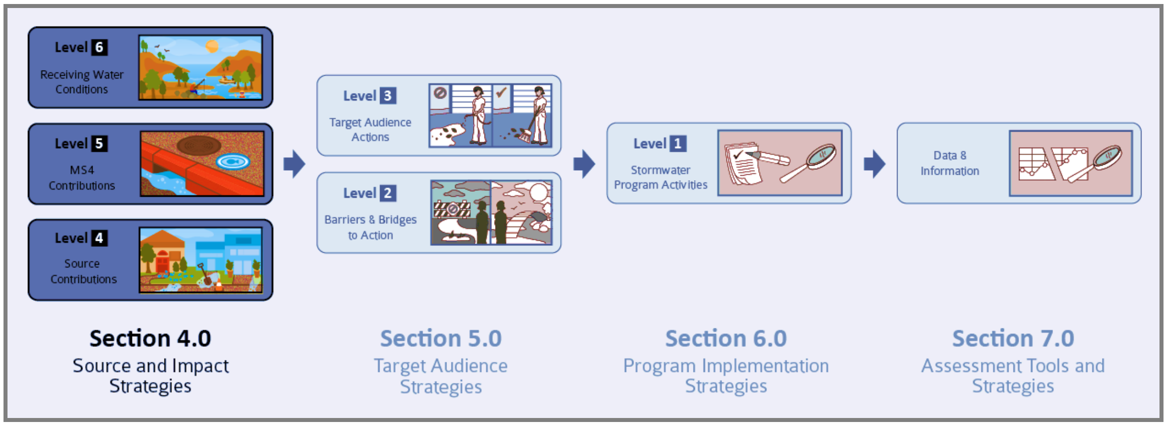


Figure ES.7: Strategic Planning Process Overview

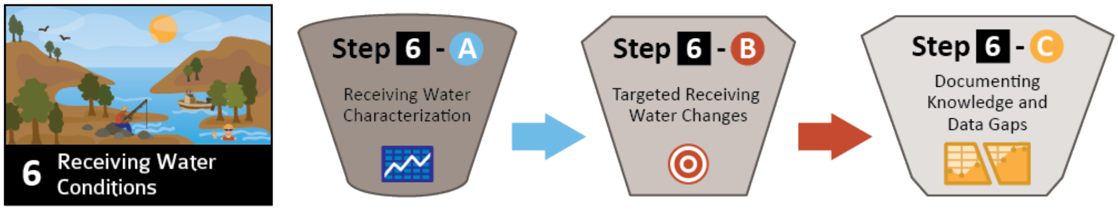
ES.4. Source and Impact Strategies (Section 4.0)



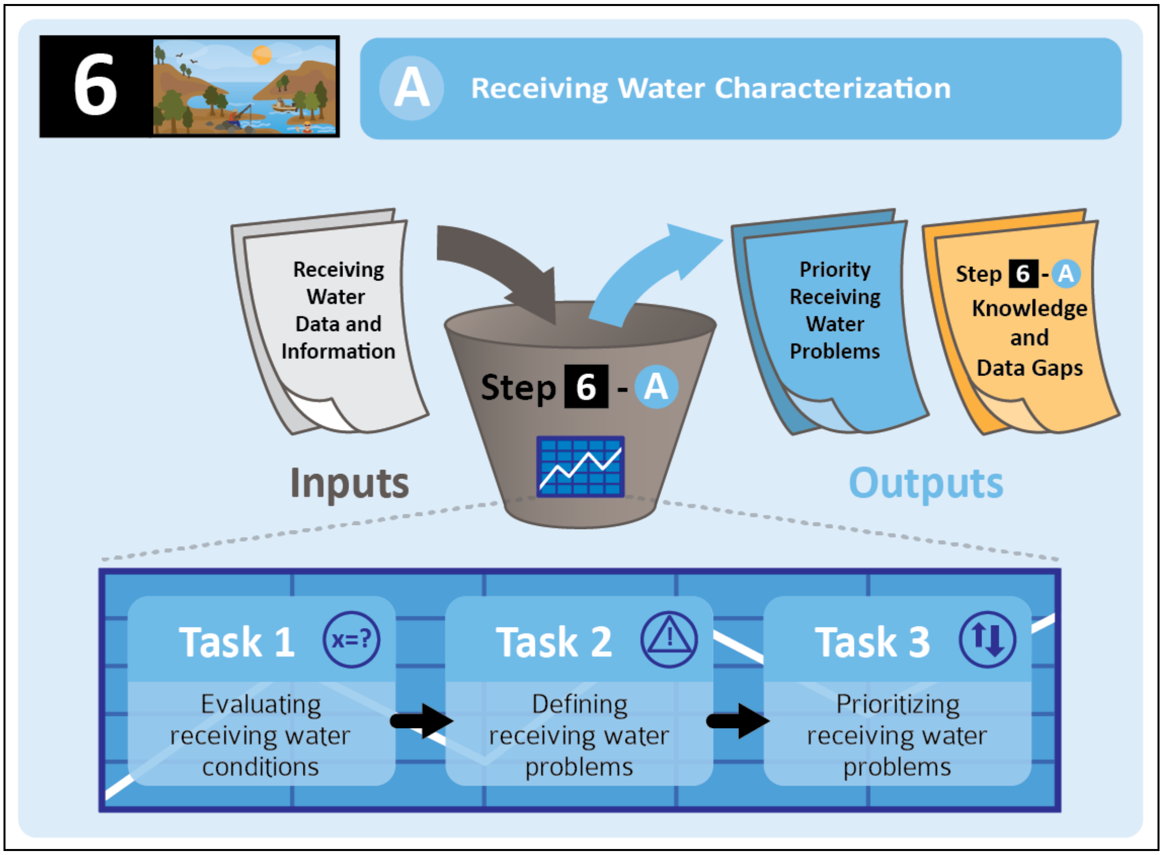
This section describes the development of **Source and Impact Strategies**. This section utilizes the strategic planning process presented in Section 3.0 to identify and prioritize sources of pollutants and flows to receiving waters. It begins with the evaluation of receiving water problems, and then “works back” toward potential contributing sources via MS4s and associated drainage areas. Following this approach, source priorities can be identified in response to demonstrated priority water quality impacts. However, since receiving water and MS4 impacts are often not well-documented, "preventive" approaches that focus primarily on the potential of sources to generate flows or pollutants must also be considered.

The development of the Source and Impact Strategies includes the following approach to evaluating outcomes for Receiving Water Conditions, MS4 Contributions, and Drainage Area and Source Contributions.

Outcome Level 6: Receiving Water Conditions



- In **Step 6-A,** managers review existing data and information to evaluate conditions in receiving waters. Initial results are then narrowed to focus on priority problem conditions.

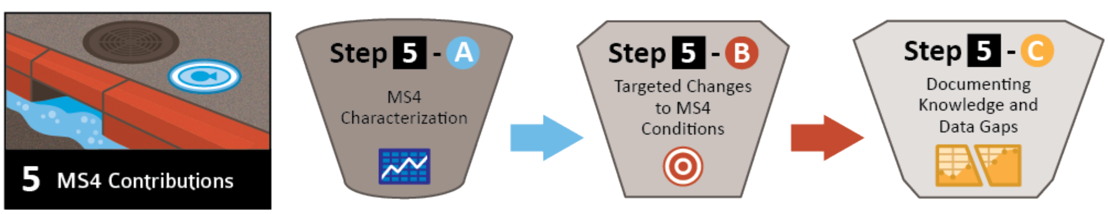


- **Step 6-B** focuses on defining the changes that will be sought in these conditions over time.

Executive Summary

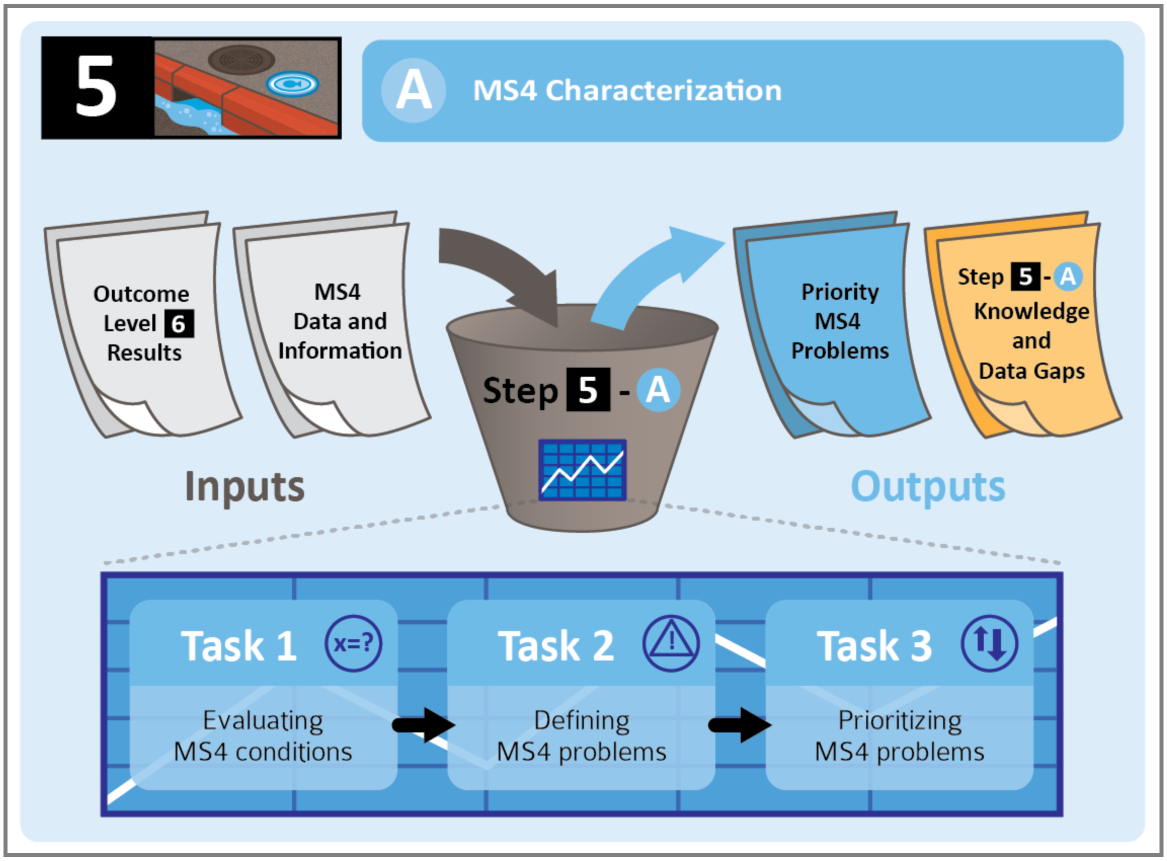
- Finally, **Step 6-C** identifies the knowledge and data gaps discovered along the way, so that future data collection initiatives can be directed toward resolving them.

Outcome Level 5: MS4 Contributions

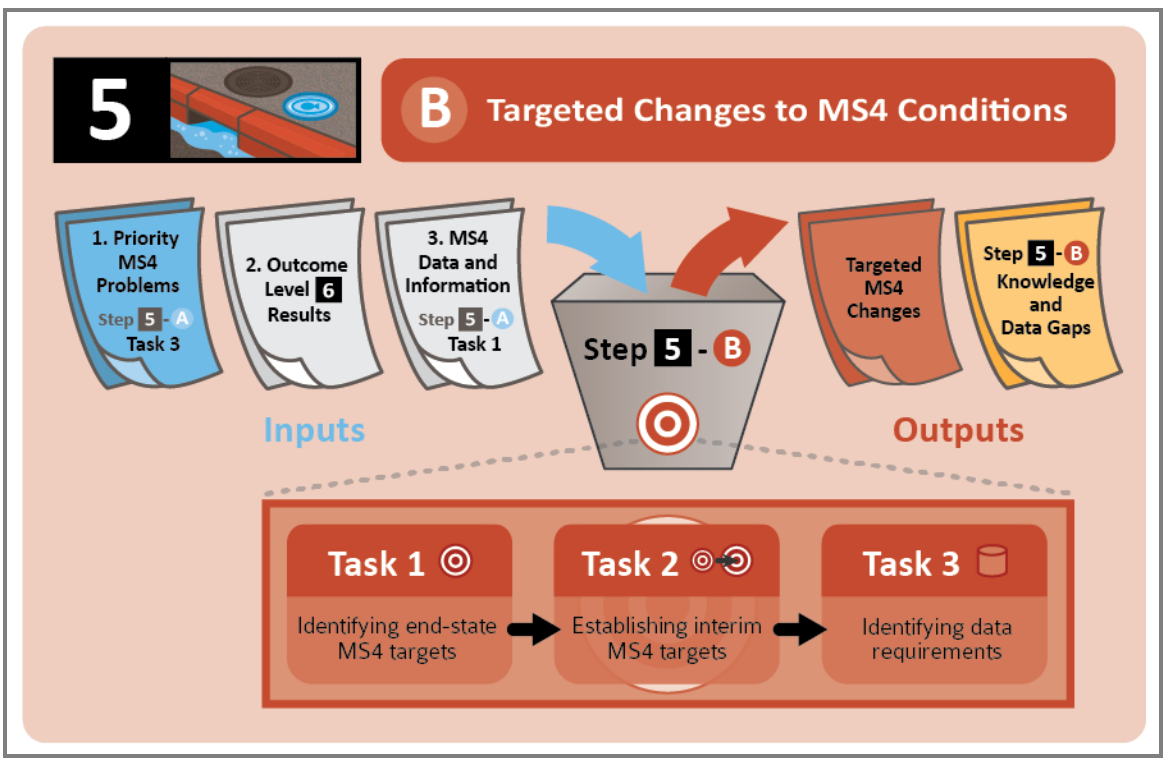


- In **Step 5-A,** managers review existing information to evaluate conditions in MS4s and contributions to Receiving Water Conditions. Results are then narrowed to focus on priority problem conditions.

Executive Summary

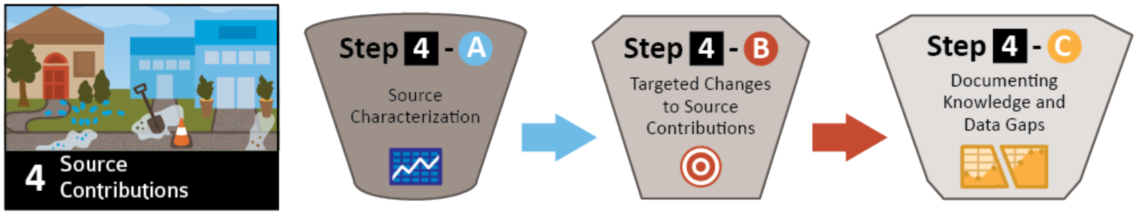


- **Step 5-B** focuses on defining the changes that will be sought in these conditions over time.

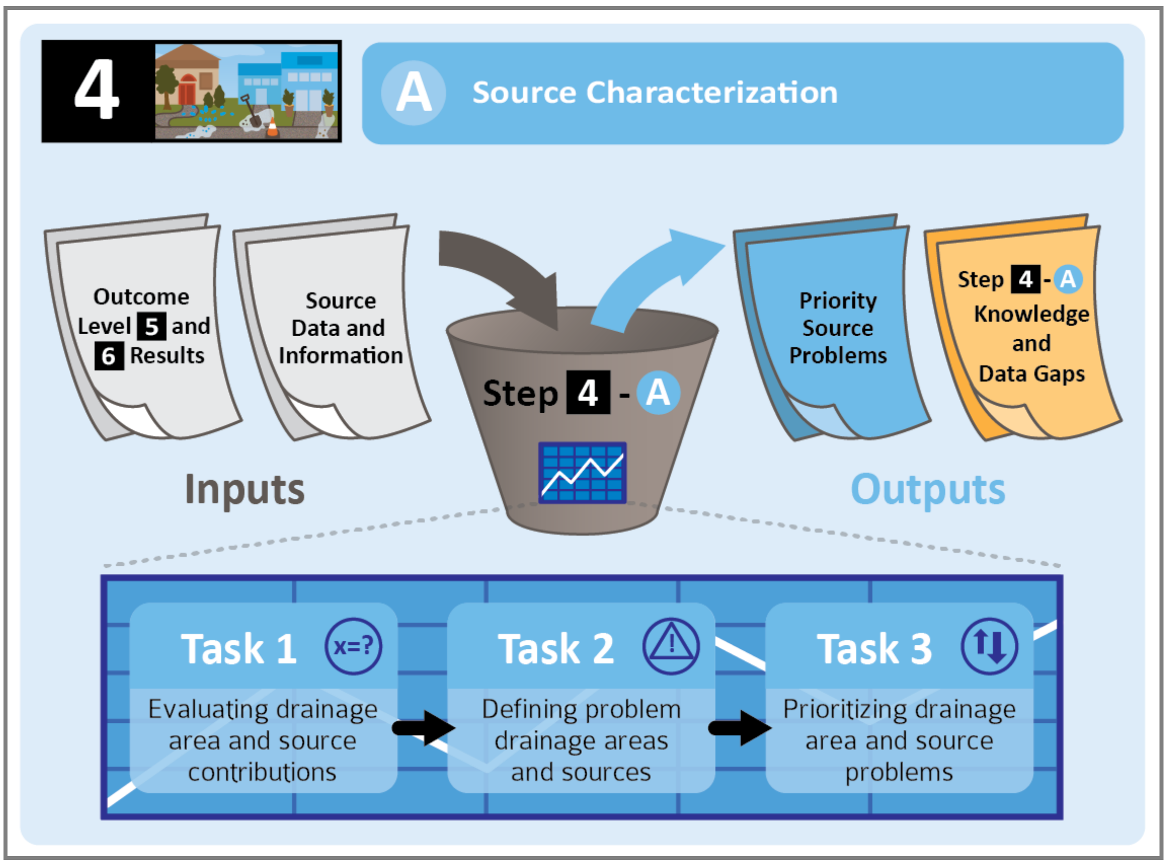


- **Step 5-C** identifies the knowledge and data gaps discovered along the way, so that future data collection initiatives can be directed toward resolving them.

Outcome Level 4: Source Contributions

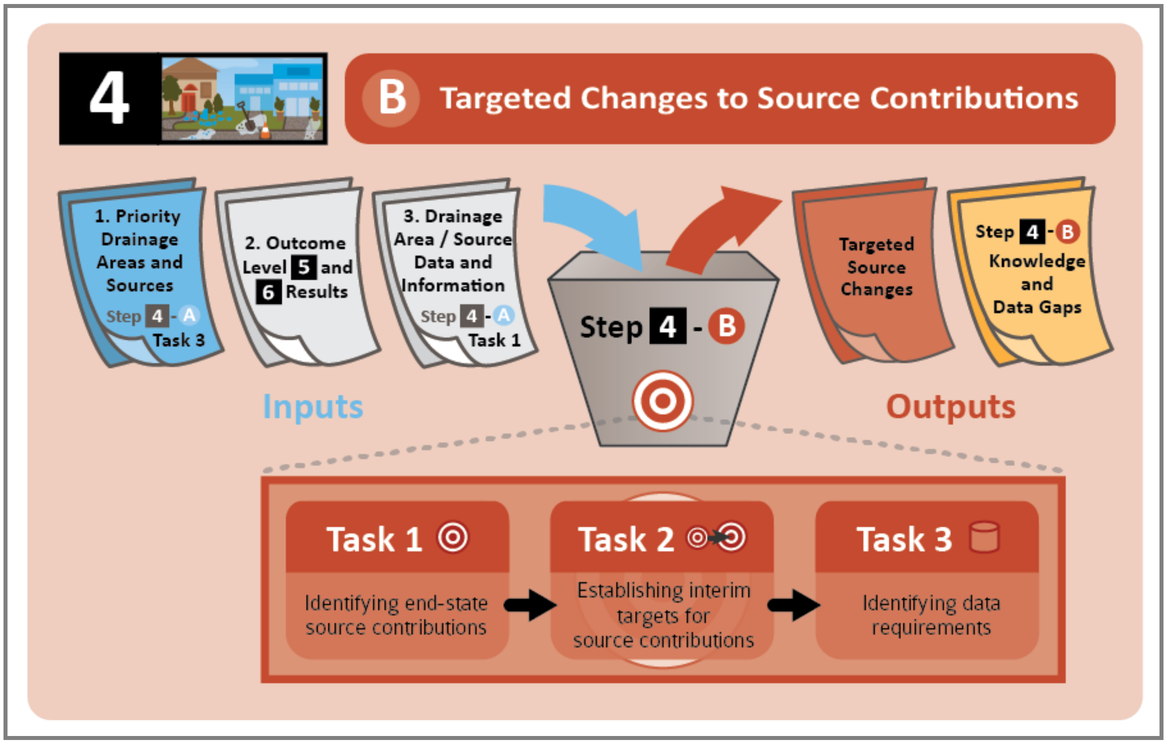


- In **Step 4-A,** managers review existing data and information to evaluate drainage areas and sources. Initial results are then narrowed to focus on contributions to priority problem conditions.



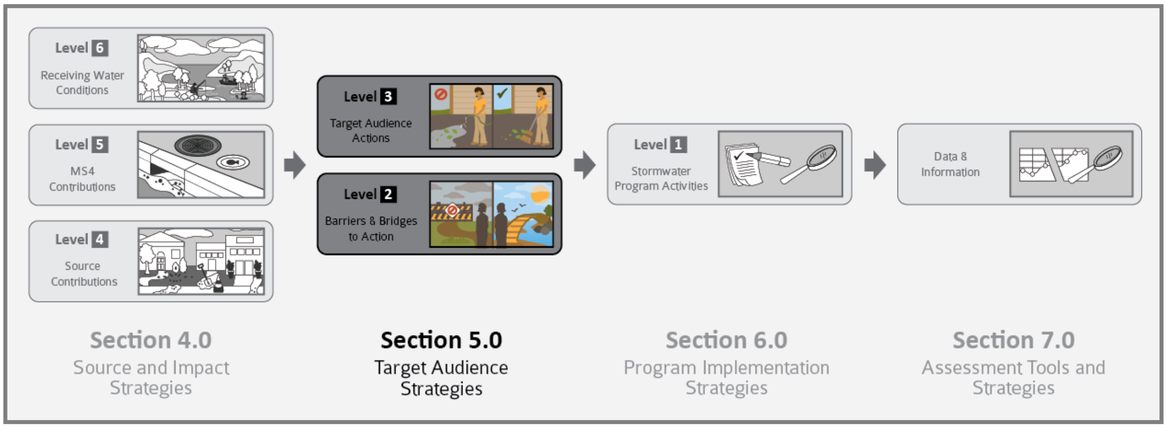
- **Step 4-B** focuses on defining the changes that will be sought in these conditions over time.

Executive Summary



- **Step 4-C** identifies the knowledge and data gaps discovered along the way, so that future data collection initiatives can be directed toward resolving them.

ES.5. Target Audience Strategies (Section 5.0)

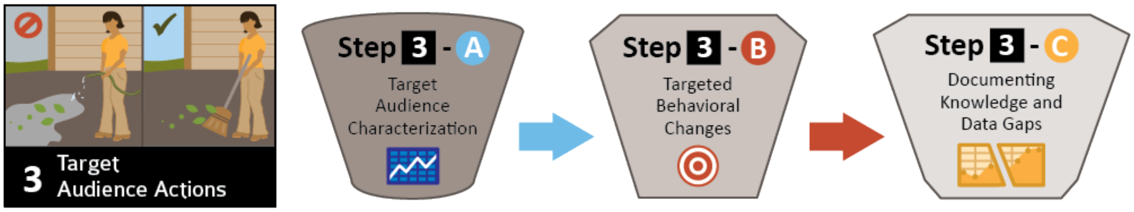


This section describes the development of **Target Audience Strategies**. Following the identification and prioritization of source contributions, as described in Section 4.0, target audience planning addresses Outcome Levels 3 and 2. Managers will focus on identifying the people that are responsible for these contributions, and then on characterizing the specific behaviors attributable to them. Ultimately, they will need to know how people should be acting differently and develop a clear understanding of the factors that may be standing in the way of desired changes.

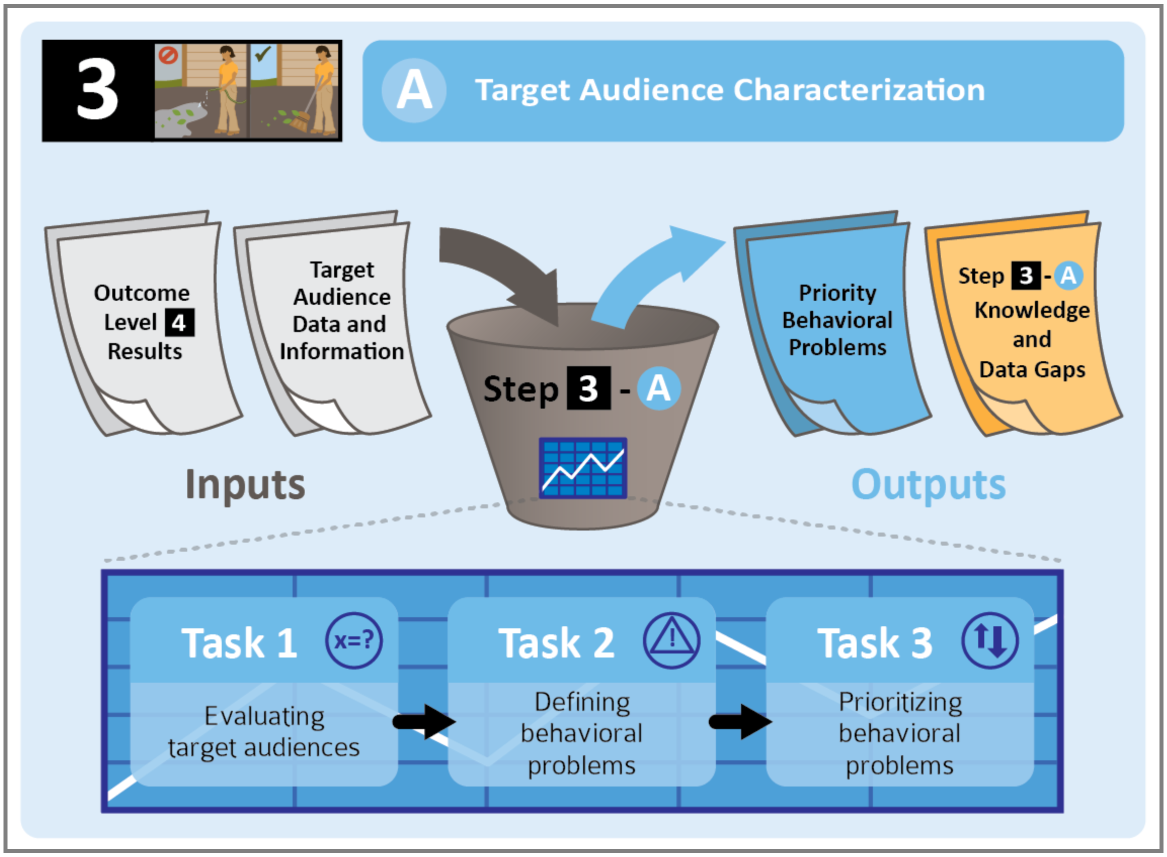
The development of the Target Audience Strategies includes the following approach for evaluating outcomes for Target Audience Actions and Bridges and Barriers to Action.

Executive Summary

Outcome Level 3: Target Audience Actions

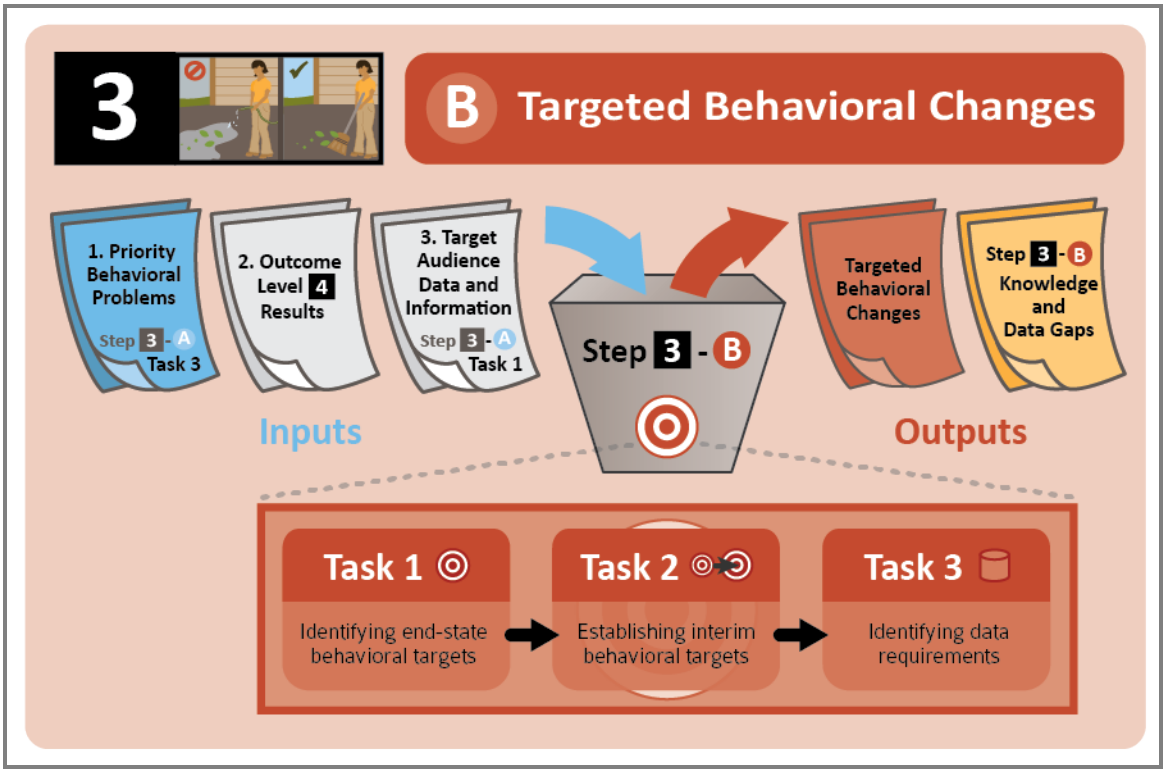


- In **Step 3-A** managers will identify, prioritize, and learn about the target audiences and their actions that may be responsible for the identified priority source contributions.



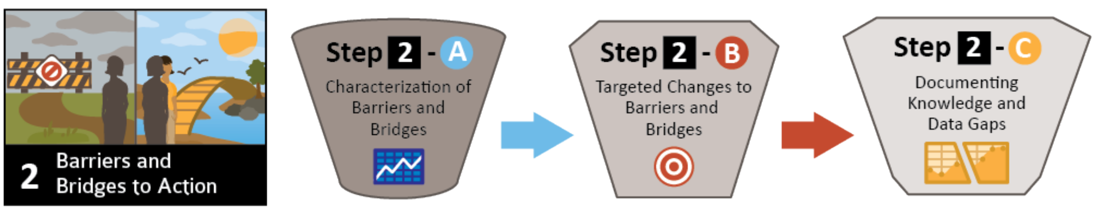
- Once priority target audiences and behaviors are identified, specific changes in them will be targeted in **Step 3-B**.

Executive Summary

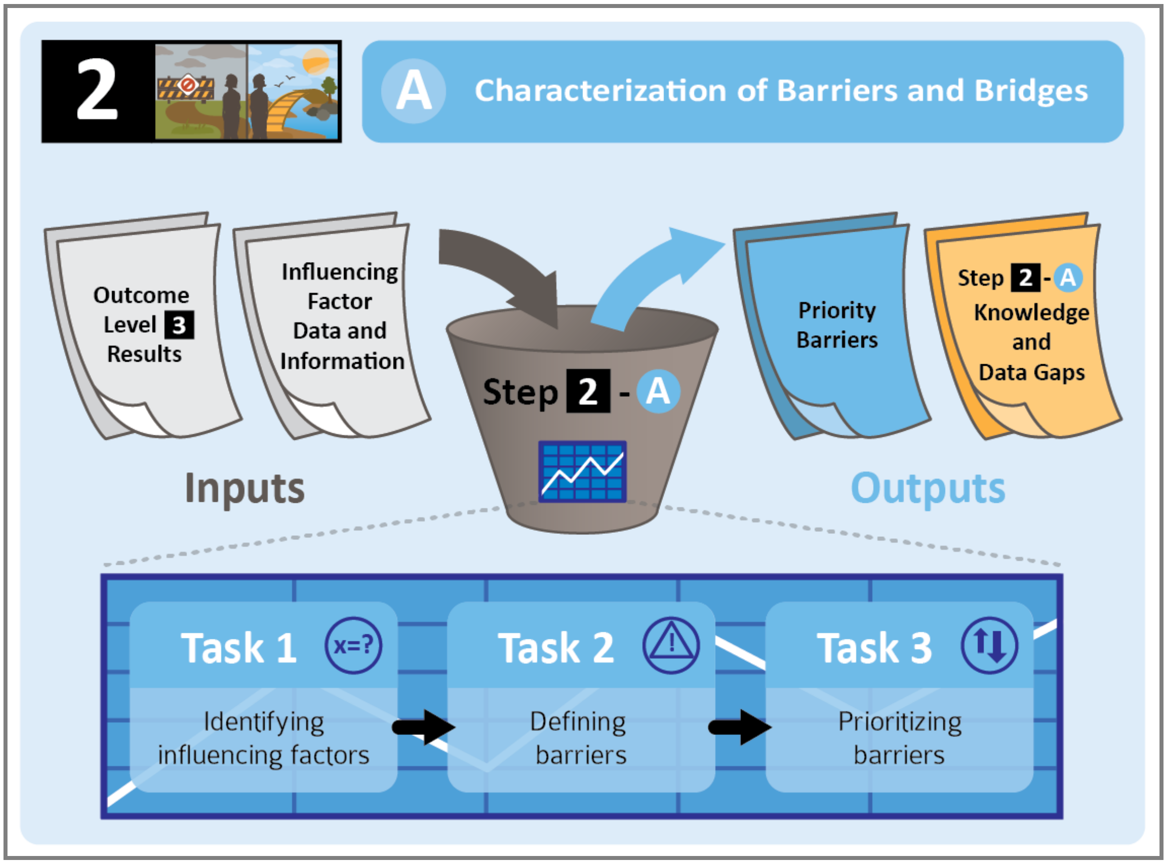


- Knowledge and data gaps will be summarized and documented in **Step 3-C**.

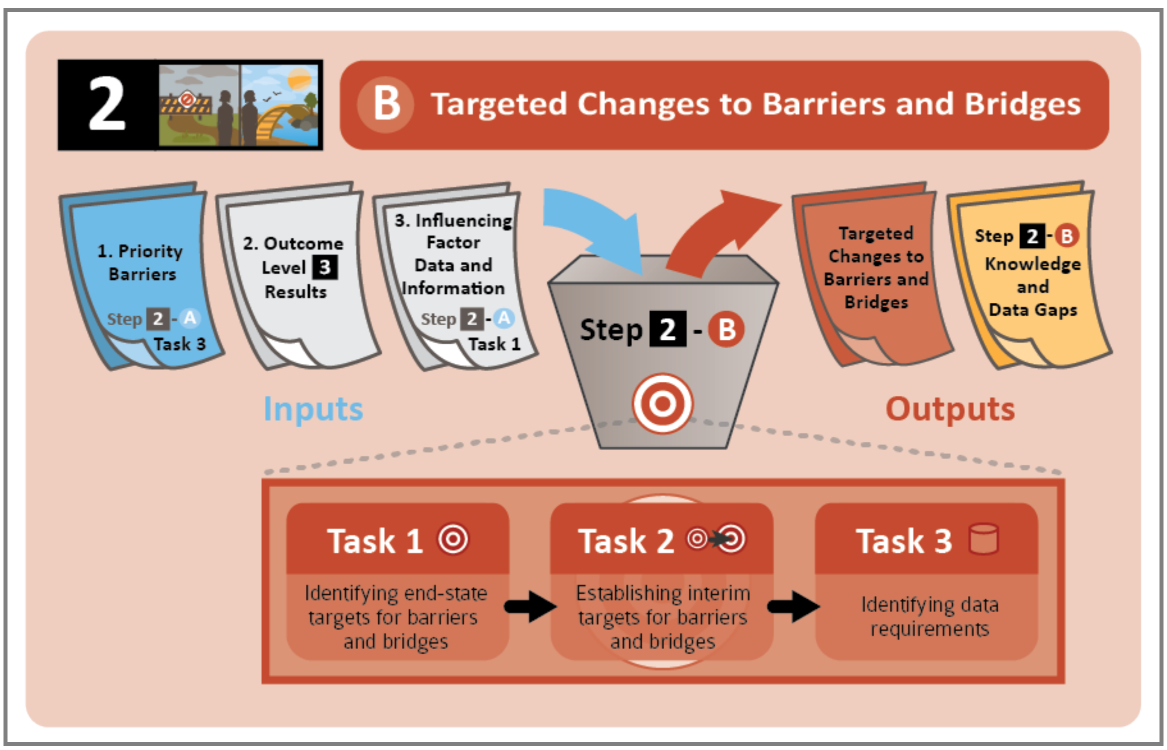
Outcome Level 2: Barriers and Bridges to Action



- In **Step 2-A** managers will identify, explore, and prioritize, the factors influencing priority target audience behaviors. An important focus of this step will be to determine how each of these might represent "**barriers**" or "**bridges**" to practices that are protective of water quality.

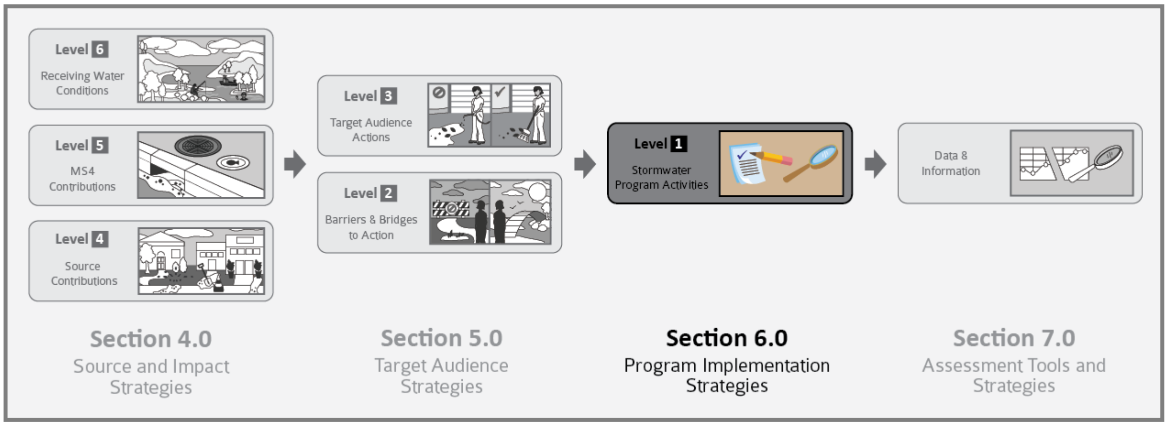


- **Step 2-B** will focus on targeting changes in factors that favor implementation of BMPs over PGAs.



- Finally, **Step 3-C** will look at the knowledge and data gaps discovered along the way.

ES.6. Program Implementation Strategies (Section 6.0)

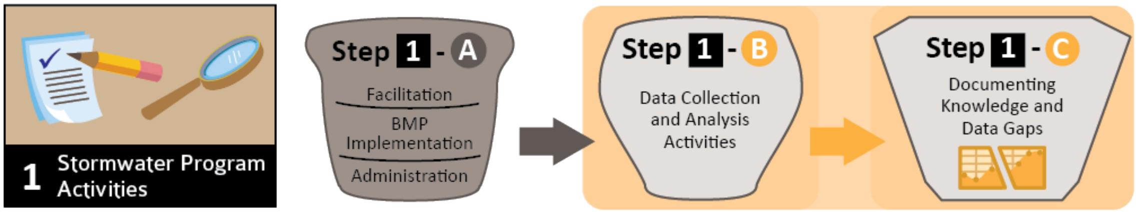


This section describes the development of **Program Implementation Strategies**. Following the completion of Target Audience Strategies, as described in Section 5.0, program implementation planning addresses Outcome Level 1. Managers will consider the target audiences, critical behaviors, and barriers and bridges already identified to develop stormwater program implementation strategies for bringing about targeted changes. Other activities needed to support general program operation and to obtain feedback for evaluating success are also considered.

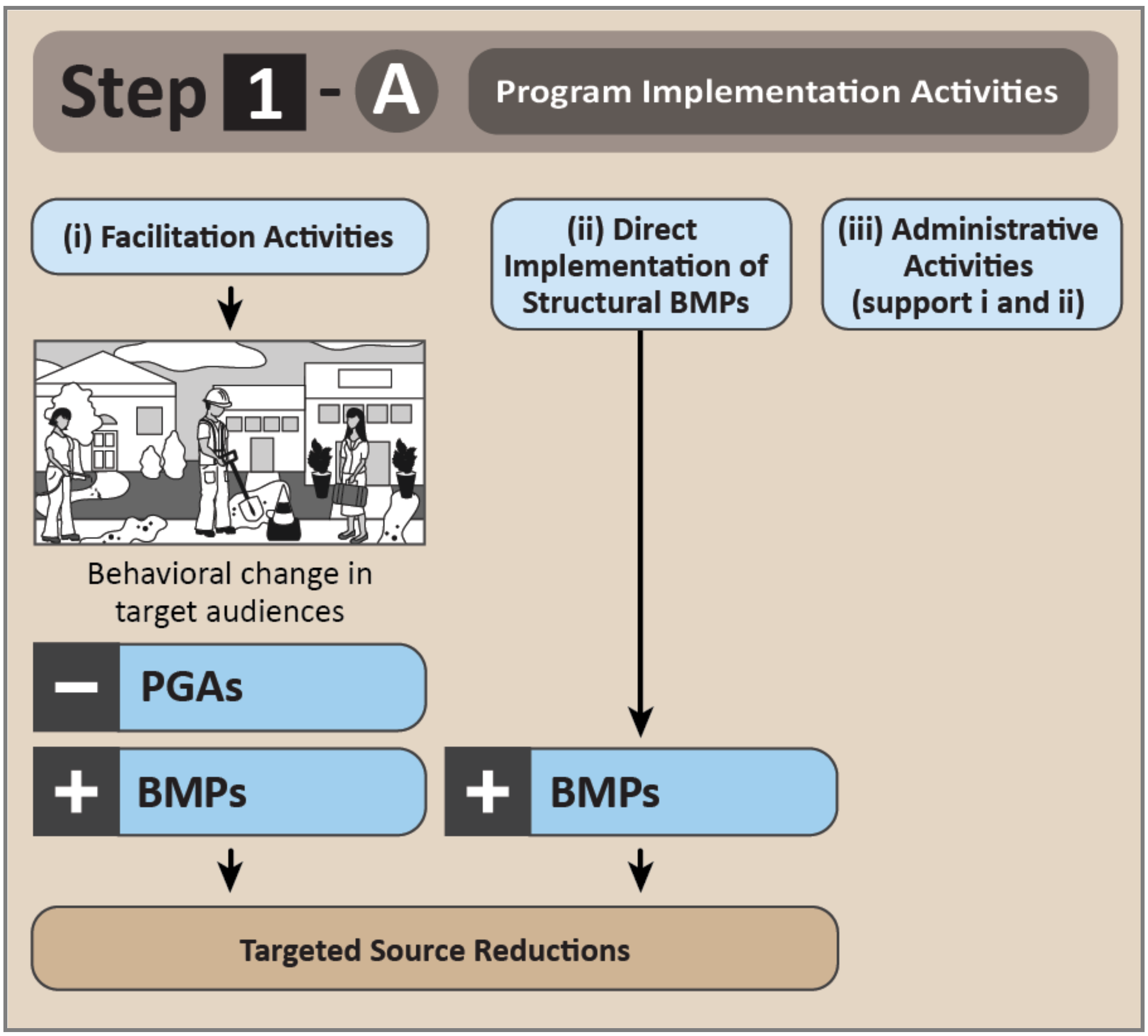
The development of the Program Implementation Strategies includes the following steps for evaluating the extent of implementation of Program elements.

Executive Summary

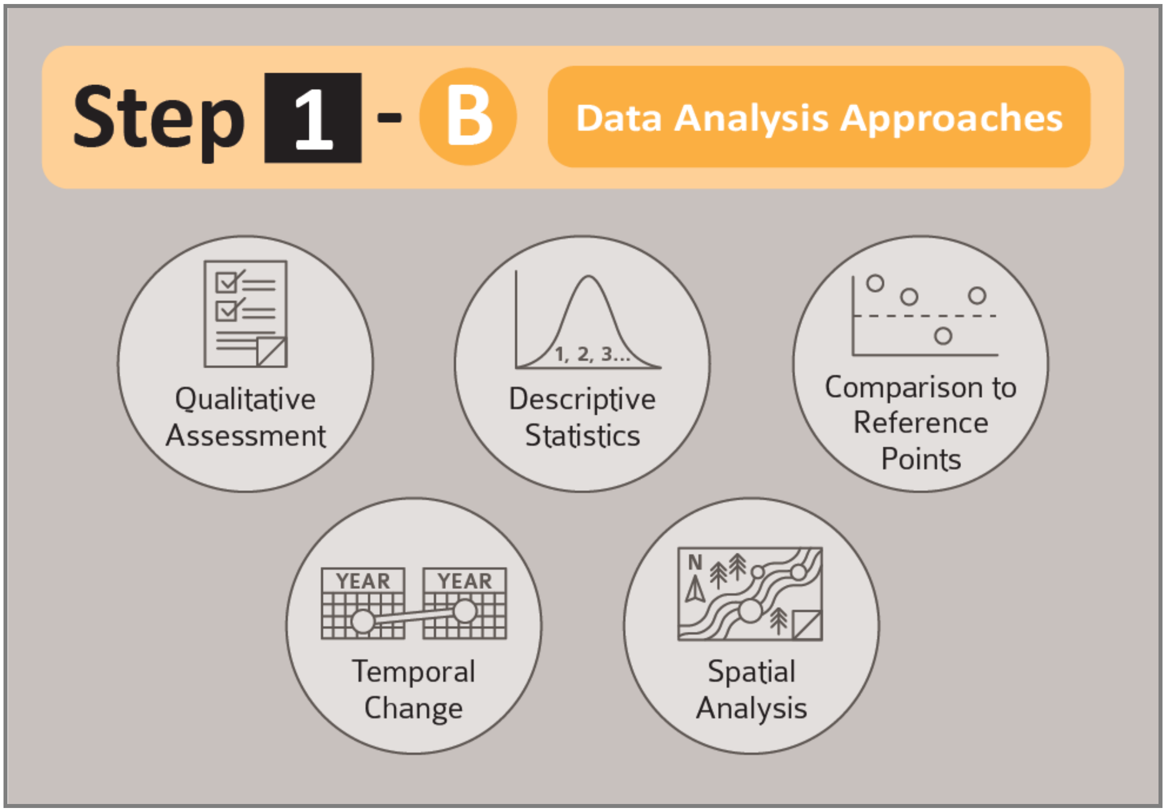
Outcome Level 1: Stormwater Program Activities



- In **Step 1-A** managers will identify the activities to be targeted during program implementation. This will initially entail the development of strategies to modify target audience behaviors, but BMPs that can be implemented directly by the stormwater program will also be identified.



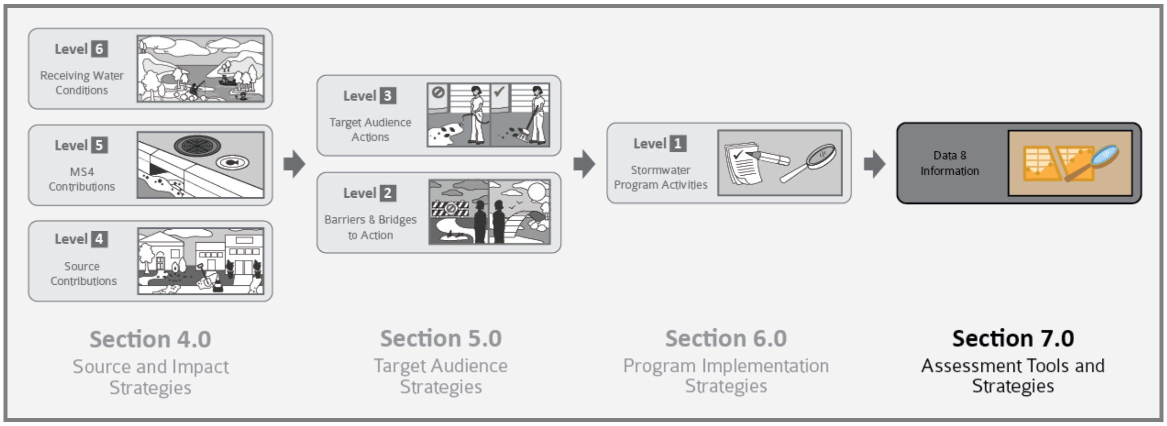
- **Step 1-B** will focus on obtaining the feedback necessary to evaluate these activities.



- Finally, **Step 1-C** will identify the knowledge and data gaps discovered along the way.

Executive Summary

ES.7. Assesment Tools and Strategies (Section 7.0)



This section describes the development of **Assessment Tools and Strategies**. Up to this point, managers will have focused on a comprehensive planning process aimed at identifying a variety of specific measurable outcomes that will define success, guide the implementation of programs, and provide the structure and measurability needed to support a meaningful adaptive management approach.

Assessment Strategy is the approach that will be used to collect and analyze data to track and assess the interim targets for each of the outcome levels. This strategy is part of an adaptive management approach that provides feedback into the program to improve its' effectiveness.

This section builds on the targeted outcomes identified in Sections 4.0 through 6.0 to provide:

- **Data Collection and Assessment Design and Implementation**: includes monitoring and study design frameworks and approaches to data collection and analysis for each of the Outcome Levels.
- **Application of Data Collection and Program Assessment Methods**: this section provides examples of how to apply these data collection and analysis and assessment methods and approaches to outcome types such as MS4 water quality, source contributions to pollutant loading, and behaviors changes for compliance at construction sites.
- **Adaptive Management**: the results from the Assessment Strategies will provide feedback to assess progress and original assumptions in order to adapt and modify the program to more effectively reach the interim and end-state goals.

The Assessment Strategy will, based on the identified targeted outcomes, metrics and timelines from each Outcome Level, identify the methodology for data collection and analysis.

ES.8. Interpretation and Use of Results (Section 8.0)

This section describes how analyses can be conducted, reported out on, and used to improve the stormwater program. Examples of effectiveness assessment are also provided.

Once the strategy for the program effectiveness assessment has been developed, the stormwater program manager should identify the data that is necessary to conduct the assessments and ensure that the approach and infrastructure for the data collection is in place. This step is critical in order to be able to conduct the desired analyses and report out on the goals and/or metrics identified within the PEA strategy.

The analyses can assist program managers in assessing progress in meeting intermediary goals, long-term goals, and identifying programmatic changes that may be necessary in order to obtain a stormwater program goal. In addition, the results may be presented to interested parties so that they may understand the benefits of the stormwater program.

Once an effectiveness assessment has been conducted, stormwater program activities should be modified, as needed, based on the results of the assessment. Modifications may include:

- Improving upon areas that did not accomplish goals;
- Expanding upon efforts that proved to be effective;
- Discontinuing efforts that may no longer be productive; or
- Shifting priorities to make more effective use of resources.

Since the development and implementation of a stormwater program is a phased effort and higher Outcome Levels often require relatively large amounts of data over a period of years, many programs will initially assess the effectiveness of the lower Outcome Levels. However, assessments should be conducted at the highest Outcome Level supported by the data, and program managers should strive to address the higher Outcome Levels as soon as possible.

The rest of the section includes examples of various effectiveness assessments that have been conducted by municipal stormwater programs throughout the state. These examples will assist other stormwater program managers in determining what metrics they may want to utilize for their program and/or how they may conduct their analyses and use the results.

Section 1.0 Introduction and Purpose

This document introduces and describes a strategic approach to planning and assessing Municipal Separate Storm Sewer System (MS4) programs. It provides background on the development and use of strategic planning methods, and describes how planning results can be used to direct program resources, establish measurability, and assess the effectiveness of stormwater management programs.

1.1 Background

Under the 1987 Amendments of the federal Clean Water Act (CWA), the USEPA developed regulations to address stormwater discharges originating from Municipal Separate Storm Sewer Systems (MS4s) as point source discharges of pollution. In California, and elsewhere in the U.S., these regulations were developed and implemented in two phases. Phase I implementation began in the early 1990s and required that operators of MS4s serving populations of greater than 100,000 people obtain permits to discharge stormwater from their outfalls. There are currently 33 Phase I Area Wide MS4 permits in California, administered through nine Regional Water Quality Control Boards (RWQCBs). These permits are re-issued on approximate five-year cycles.

The second phase of MS4 regulations became effective in March 2003. The California Phase II Permit (WQ Order No. 2003-0005-DWQ) extended permit coverage to smaller municipalities, including nontraditional Small MS4s, which are governmental facilities such as military bases, public campuses, state parks and prison and hospital complexes. An updated Phase II Permit (Order No. 2013-0001 DWQ), re-issued statewide through the State Water Resources Control Board (SWRCB), became effective in July 2013.

For a number of reasons, MS4 programs are inherently complex, often more so than other water quality and environmental programs. The first of these is that they typically address a number of major sources within their areas of jurisdiction; construction and development

A **Municipal Separate Storm Sewer System (MS4)** is a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) 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;
- Not a combined sewer; and
- Not part of a Publicly Owned Treatment Works (POTW) (sewage treatment plant).

Stormwater runoff is commonly transported through MS4s and often discharged untreated into local waterbodies.

sites, residential areas, municipal operations, and industrial and commercial facilities. Even a small municipality must establish and administer a program to thousands of individuals, sites, and sources. Larger municipal programs can easily address millions of individuals, sites, or sources. While it makes sense to apply these programs broadly, successful implementation depends on the unique behavioral responses of the people they're directed to. Planning and assessment must, therefore, reflect these differences but also support meaningful analysis at a broader programmatic level.

Guidance on planning and assessing stormwater programs is needed by Phase I and Phase II MS4 stormwater program managers. MS4 programs can be particularly challenging to plan and assess because they:

- Address multiple major sources of stormwater pollution,
- Focus predominately on the use of source control best management practices, and
- Must prevent discharges of pollutants and flow that are co-mingled via manmade and natural, open systems.

Another feature of MS4 programs adding to their complexity is that, due to their extensive geographic coverage, vast number of potential pollutants[1], and the volume of flows addressed, they tend to focus predominantly on the use of source control best management practices (BMPs), (e.g., good housekeeping practices, pesticide use reduction, picking up after pets, etc.). While treatment controls are also an important part of MS4 programs, managers often find themselves seeking to bring about the broad-scale implementation of many very small controls by third parties. More often than not, they have limited control over outcomes and lack the specific feedback needed to determine if these practices were implemented or are effective. Moreover, because source controls can often be difficult to measure, and the individual impact of many of them is very small, it is difficult to paint a clear picture of their collective performance.

Managers must also consider the overall characteristics of discharges within and from their MS4s. The flows in an MS4 are transported via both manmade and natural, open systems. Contrast this, for example, with to the flows in a wastewater system (e.g., sinks, toilets, etc.), the components of which are completely anthropogenic and contained. The ability to measure, modify, or control MS4 discharges is complicated by the co-mingling of both anthropogenic and natural flows and pollutants within these systems. In addition, MS4s are often impacted by a number of non-point sources such as groundwater seepage, wind-blown and directly-deposited materials, and aerial deposition.

[1] About 23 million substances have been indexed by the American Chemical Society's Chemical Abstracts Service.

Despite these and other challenges, stormwater program managers find themselves facing increasing pressure to demonstrate the effectiveness of their programs, often with little guidance on how to do so. **Effectiveness assessment** consists of the methods and activities that managers use to evaluate how well their programs are working and to identify modifications necessary to improve results. Without the specific knowledge or the tools needed to do so, stormwater managers can be faced with a perception that their programs are inadequate or failing.

1.2 Purpose

The primary purpose of this Guidance Document is to establish an up-to-date and specific "how to" guidance for managers in planning and assessing their MS4 programs. It approaches effectiveness assessment as an integral part of a comprehensive **strategic planning** process. It is designed for use by MS4 program managers involved in developing and implementing all aspects of stormwater programs, but it should also be useful to a variety of dischargers regulated under other stormwater permits and programs (e.g., construction and industrial), as well as other environmental managers with a need for guidance on management and assessment principles.

Throughout this document, managers will find a consistent emphasis on the following key principles:

- ***Strategic planning*** -- Managers will learn how to "plan for assessment." During planning, they'll follow a consistent and logical structure to establish measurable targets that can later be used to evaluate implementation results and determine success.
- ***Structure and measurability*** – A standardized classification of "outcomes" is introduced to direct programs toward measurable and meaningful endpoints. By exploring "cause and effect" relationships between different outcome types, managers will incrementally improve their understanding of what works and what doesn't.
- ***Prioritization*** – Albert Einstein once said "not everything that can be counted counts, and not everything that counts can be counted." Stormwater managers have neither the ability nor the resources to track or to evaluate every measurable outcome, and must therefore focus their limited resources where they most matter.
- ***Sustainability*** – Stormwater management is more than a technical exercise. Every decision that managers make comes at a cost, and has potential implications to individuals, the environment or society as a whole. Decision-making processes in this document are approached through a balanced consideration of regulatory, technical, economic, and social factors.

In recent years, effectiveness assessment has begun to emerge as a distinct discipline within the broader stormwater program management field. Leading the way, the California Stormwater Quality Association (CASQA) released its *Municipal Stormwater Program Effectiveness Assessment Guidance* in May 2007. Since its release, this document has been used in interactive training workshops with Phase I and Phase II municipal stormwater program managers and staff, as well as regulators in California. It was also the primary reference for a 2008 USEPA webcast on effectiveness assessment, and has been incorporated into other regulatory guidance documents. See for example, USEPA's *MS4 Program Evaluation Guidance* manual (USEPA 2007) and *Evaluating the Effectiveness of Municipal Stormwater Programs* document (USEPA 2008).

Reissued California Phase I and Phase II municipal stormwater permits are also increasingly reflective of the 2007 CASQA Guidance, in large part due to the March 2011 release of the *Guidance for Assessing the Effectiveness of Municipal Storm Water Programs and Permits* by the State Water Resources Control Board. California Assembly Bill 739 (Laird, 2007) required the SWRCB to develop this guidance in accordance with the general effectiveness assessment principles established through CASQA, and required the SWRCB and Regional Water Quality Control Boards to utilize the document when establishing assessment requirements for programs and permits.

Considerable experience has been gained since CASQA initially began its program effectiveness assessment work in 2004. To this end, this updated Guidance Document reflects new information, lessons learned, and the refinement of assessment concepts over that period.

A structured and well-executed approach to planning and assessing stormwater programs can help managers to ensure that their programs are properly targeted, determine whether intended results are being efficiently and cost-effectively achieved, and, ultimately, relate implementation results to conditions in urban runoff and receiving waters. Moreover, when considered as part of a larger program planning process, assessment principles and approaches can help to guide managers toward implementation strategies with the greatest opportunity for long-term success.

1.3 Organization

Table 1.1 provides an overview of the organization of this Guidance Document, and briefly describes the purpose of each section. It is generally structured to follow the strategic planning process introduced in Section 3.0 (Introduction to Strategic Planning for Stormwater Management Programs). Sections 4.0 through 6.0 provide detailed guidance on applying these strategic planning principles to the three primary components of the stormwater management model introduced in Section 2.0 (General Concepts and Principles). The intent of these sections is to help managers develop defensible strategic planning approaches that fully incorporate targeted, measurable outcomes which can be used to assess and improve their programs over time. Sections 7.0 and 8.0 provide additional discussion of options and approaches for assessing the data and information collected during the implementation phase.

Table 1.1: Organization of the Guidance Document

1.0	**Introduction and Purpose**	Section 1.0 provides background on the development and use of effectiveness assessment methods, and explains their importance to stormwater program managers.
2.0	**General Concepts and Principles**	Section 2.0 introduces the main components of the program planning and assessment processes, describes their use, and defines standardized concepts and terminology used throughout the remainder of the Guidance Document. These general concepts provide a basis for the specific instruction provided in the remainder of the document.
3.0	**Introduction to Strategic Planning for Stormwater Management Programs**	Section 3.0 builds on the concepts and principles presented in Section 2.0. It describes a stepwise process for developing a Comprehensive Program Planning Strategy. This includes problem characterization, goal setting, selection of control strategies and program activities, and the establishment of methods and metrics to assess effectiveness.
4.0	**Source and Impact Strategies**	Section 4.0 applies the strategic planning process introduced in Section 3.0 to the development of Source and Impact Strategies.
5.0	**Target Audience Strategies**	Section 5.0 applies the strategic planning process introduced in Section 3.0 to the development of Target Audience Strategies.
6.0	**Program Implementation Strategies**	Section 6.0 applies the strategic planning process introduced in Section 3.0 to the development of Program Implementation Strategies.
7.0	**Assessment Tools and Strategies**	Section 7.0 identifies and discusses tools and strategies for conducting assessments.
8.0	**Interpretation and Use of Results**	Section 8.0 provides examples of effectiveness assessments that have been conducted by stormwater programs throughout the state. These are intended to provide concrete examples of how others have approached assessment, and how mangers might approach the analysis and use of results.
Att. A	**Glossary of Acronyms and Terms**	Attachment A defines key acronyms and terms used throughout the document.

Att. B	**Source Profiles**	Attachment B provides additional background information on the following source categories: 1. Planning and land development sources and activities 2. Construction sources and activities 3. Industrial and commercial sources and activities 4. Municipal operations sources and activities
Att. C	**Constituent Profiles**	Attachment C provides additional background information on the following common constituents: 1. Bacteria 2. Sediment 3. Nutrients 4. Mercury 5. Pesticides 6. Trash

Section 2.0 Stormwater Management Approach

This section describes the primary components of a comprehensive Stormwater Management Approach. Within these components, six types of Outcome Levels are introduced. Outcomes are the backbone of the strategic planning and assessment processed described in this document. They provide the structure and measurability needed to evaluate and improve Stormwater Management Programs over time.

2.1 Background

Management approaches share a number of important similarities while the details of individual programs vary. Before looking further into specific planning and assessment approaches, it's useful to review the general model on which they're based.

2.2 Primary Components

For the purposes of this document, stormwater management consists of three primary components:

- **Sources and Impacts** – This component addresses the generation, transport, and fate of urban runoff pollutants and flows. It includes sources (sites, facilities, areas, etc.), stormwater conveyance systems (also referred to as called Municipal Separate Storm Sewer Systems, or MS4s[1]), and the water bodies that ultimately receive source discharges via MS4s (receiving waters).
- **Target Audiences** – This component focuses on understanding the behaviors of the people responsible for source contributions. It explores the factors that determine existing behavioral patterns and looks for ways to replace polluting behaviors with nonpolluting behaviors.
- **Stormwater Management Programs** – Stormwater programs are the road map for the improvements that managers wish to attain in receiving water beneficial uses. Their immediate purpose is to describe the programs that will facilitate changes in the behaviors of key target audiences; however a number of administrative and data gathering functions also need to be considered during planning and assessment.

Figure 2.1 illustrates the general relationship of these three components and introduces six different Outcome Levels and general Outcome Types associated with them.

[1] Pollutants and flows can also be introduced to receiving waters via other pathways (overland flow, direct discharge, aerial deposition, etc.). This document only focuses on the MS4 pathway.

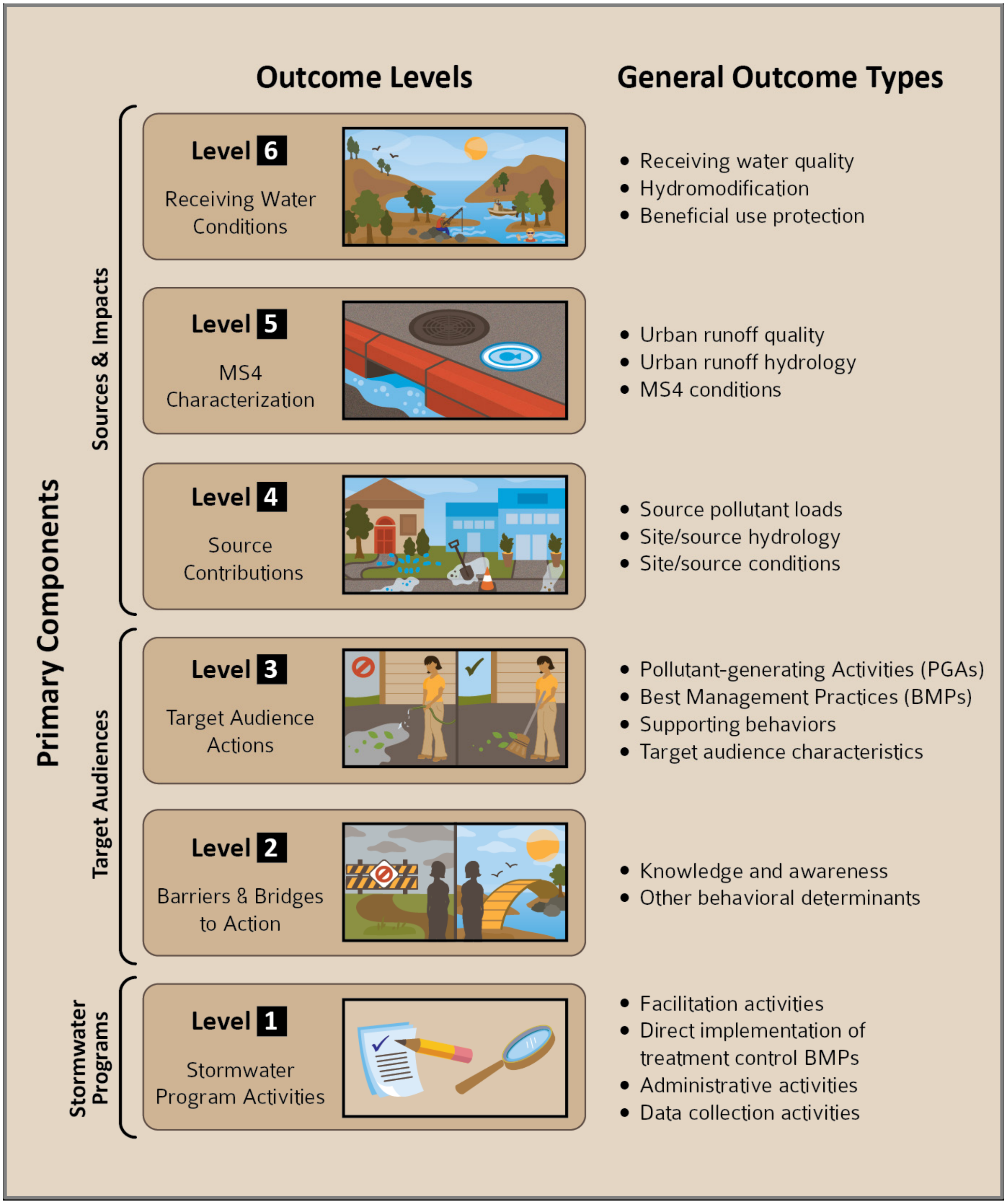


Figure 2.1: General Stormwater Management Model

2.3 Introduction to Outcomes

Outcomes are measurable endpoints associated with programs, people, and physical systems. They are the building blocks of the management approach described in this document. Outcomes establish the measurability and structure needed to successfully complete the various planning and assessment tasks described throughout this document. Because a variety of outcomes must be considered when planning and assessing programs, it's helpful to place them within a framework that provides a logical and understandable context.

Outcomes are grouped according to the six categories, or Outcome Levels, shown in **Figure 2.1**. Starting with Level 1 and moving sequentially toward Level 6, they represent a general progression of conditions that are assumed to be related in a sequence of causal relationships. That is, conditions at any one level may influence conditions at the next highest level. For example, knowledge and awareness (Level 2) in target audiences will likely influence their behaviors (Level 3).

While it may initially seem counterintuitive, managers will normally address the six outcome levels in "reverse order" (from Level 6 to Level 1) during planning and assessment (**Figure 2.2**). The reason for this is that, in practice, they must work backwards from measured or observed effects to try and establish their causes.

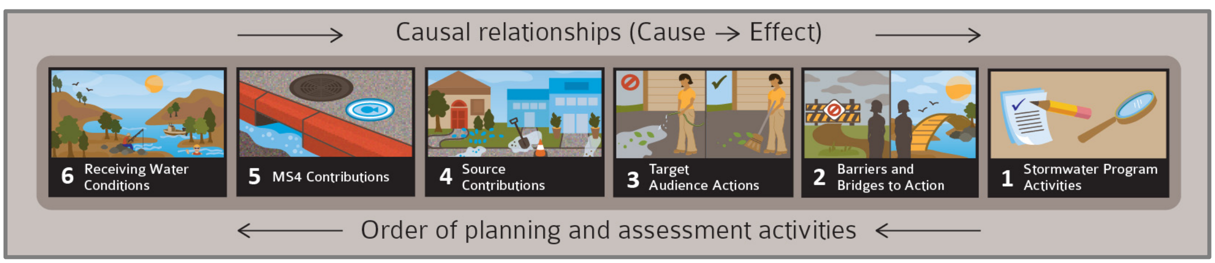


Figure 2.2: The "Counterintuitive" Order of Planning and Assessment Activities

While it can be tempting to conclude that higher numbered Outcome Levels have greater importance, in practice, each plays a critical role in supporting effective management decisions because we do not completely understand all of the relevant variables and relationships between the variables. Level 6 outcomes are the most direct expression of desired water quality conditions. However, even when they can be demonstrated, it may be difficult to relate them back to specific management measures. To fully appreciate the inherent and unique value of each Outcome Level, it's useful to visualize them as a chain of six links (**Figure 2.3**).

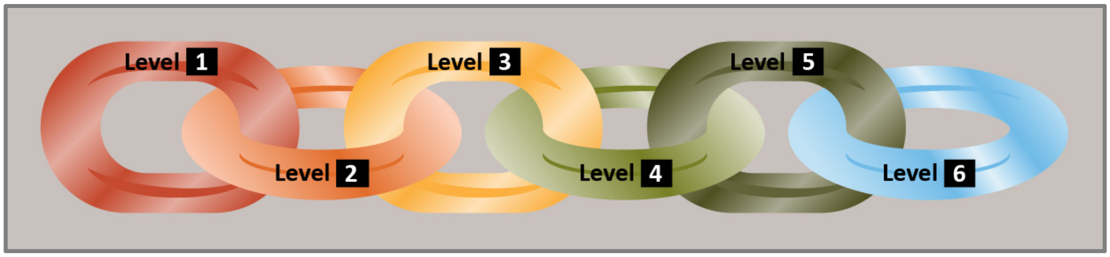
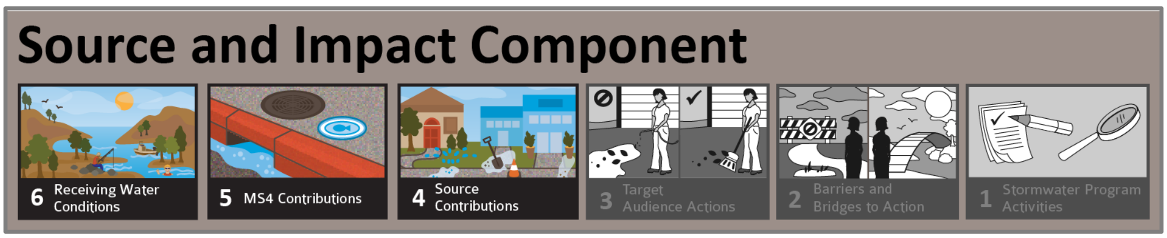


Figure 2.3: Outcome Levels as a Chain of Six Links

Similar to the saying “a chain is only as strong as its weakest link”, it’s also true that the design and assessment of Stormwater Management Programs requires a recognition and understanding of each Outcome Level both individually and in relation to the others that are influenced by it. This is critical in order for the Program to be measurable and effective in the long term. Each of the six individual outcome levels is introduced below within the context of the general component in which it occurs.

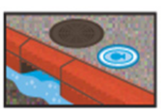


The **Source and Impact Component** is the physical component of the management approach, i.e., it deals with the generation, transport, and fate of pollutants and flows from the urban environment. It encompasses Outcome Levels 6, 5, and 4. During planning and assessment, managers will consider a variety of parameters to characterize water quality and hydrologic conditions at sources, within MS4s, and in receiving waters. Once problem conditions are identified and prioritized, goals for change can be established and strategies developed for achieving them. The starting point for Source and Impact planning and assessment is Outcome Level 6.

The primary objective of stormwater management programs is the protection of water bodies receiving discharges from MS4s. Level 6 outcomes describe receiving water conditions. They can apply either to existing conditions or to improvements that will be sought over time through program implementation. They can include virtually any chemical, biological, or physical parameter that can be measured or assessed in receiving waters (i.e., chemical concentrations, dissolved oxygen levels, biological integrity, species diversity, eutrophication, microbiological or toxicological conditions, hydromodification, or trash). Level 6 successes are best expressed through the attainment of beneficial uses, traditionally measured as compliance with water quality objectives (WQOs). This is important, but managers should also identify receiving water conditions that they consider to be problematic even if the corresponding WQOs have not been exceeded.

Receiving water conditions can be helpful in assessing overall program effectiveness, but such conclusions should be drawn with extreme caution. Changes in these conditions usually lack specific, direct linkages to other outcome types and require extended periods of monitoring and analysis to confirm. Moreover, receiving water conditions usually reflect multiple influences and inputs other than stormwater discharges (e.g., sanitary sewer overflows, rising groundwater, agricultural or other non-point discharges, or aerial deposition). The vast number of potential pollutants and contamination pathways in the environment require that conclusions regarding management measure effectiveness include corroborating assessments from multiple outcome levels.

In California, most Phase I municipal stormwater programs have had receiving water monitoring programs in place for at least fifteen years. Although these programs provide a fairly extensive record of receiving water data and results, they reflect a period of rapid change in stormwater program implementation as well as urbanization. This record will be an important reference for future data comparisons.



5 MS4 Contributions

Level 5 outcomes apply exclusively to MS4s, but are similar to the Level 4 Outcomes described below because both deal with discharges. The difference is that Level 4 Outcomes apply to discharges up until the point that they leave a source (a facility, a property, etc.), but once a discharge of pollutants or flow enters the MS4 (i.e., in a gutter, on the street, into a storm drain, etc.) it is considered “urban runoff.” Level 5 conditions may be measured within the MS4, or as discharges from it. In either case, evaluation typically focuses on flow conditions, pollutant concentrations or loads, or both.

Because Level 5 Outcomes provide a direct linkage between sources and receiving water impacts, they can provide a conceptually straightforward means of gauging program effectiveness, and a basis for refining efforts over longer periods of time. In practice, Level 5 outcomes are extremely challenging to quantify. MS4 conditions tend to be highly variable both spatially and temporally. This can make it difficult to establish baselines, determine trends, and evaluate results. Moreover, it can be challenging to establish linkages between pollutants in MS4 discharges and any of the numerous sources where they may be generated, especially given the co-mingling that can occur from sources within the MS4.

4 Source Contributions

Level 4 Outcomes address sources and discharges from them. A **Source** is anything with the potential to generate urban runoff flow or pollutants prior to their introduction to the MS4. Most stormwater programs address a variety of sources corresponding to the major sectors of existing and new development. Typical examples are presented in **Table 2.1**.

Table 2.1: Major Source Categories and Examples of Specific Source Types

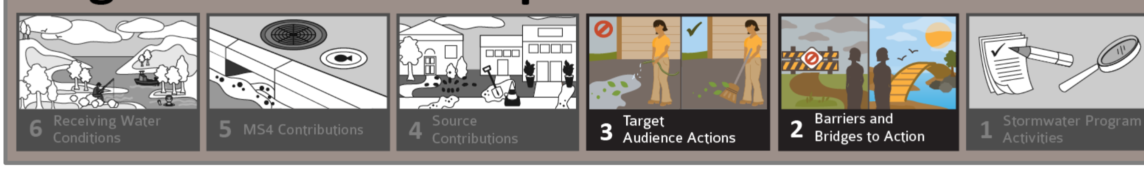
Municipal Sources	Residential Sources	Industrial & Commercial Sources	Construction & Development Sources
• Solid waste facilities • Wastewater operations • Streets and roads • MS4s • Parks	• Single family housing • Multiple family housing • Apartments • Mobile homes • Rural residential areas • Inner city neighborhoods	• Restaurants • Automotive maintenance • Nurseries • Horse stables • Mobile operations (landscaping, pool care, pest control, etc.)	• Commercial and industrial development • Single family homes • Major subdivisions • Capital improvement projects • Redevelopment sites

Source contribution can refer either to a source loading or to a reduction in that loading. **Source loadings** are the flows and pollutant loadings added by sources to a MS4. **Source reductions** are changes in the amounts of pollutants or reductions in flow associated with specific sources before and after control measures are employed. Because source loadings ultimately reach receiving waters through MS4s, managers stand to benefit from a better understanding of how they can be reduced.

Source contributions provide a crucial linkage between target audience behaviors and MS4 discharge quality. In practice, it's often not possible to directly measure source contributions. Instead, managers often rely on estimates of **source potential** (also expressed as **threat-to-water-quality**). Source potential describes the likelihood that a given source type will discharge flows or pollutants during wet or dry weather conditions. Since individual sources can't be observed all the time, managers must often rely on such estimates to gauge their relative importance.

Section 4.0 will introduce a number of conceptual approaches for estimating source loadings or reductions. Unfortunately, very few of these involve direct measurement, so they tend to be most useful for comparison. This means that even though permit requirements are increasingly focusing on quantifying source reductions, managers have yet to find more than a handful of approaches that are practical or affordable, or that go beyond the broad-scale application of assumptions and estimates. Overcoming these limitations is one of the greatest challenges for source contributions.

Target Audience Component



The **Target Audience Component** is the behavioral portion of the management approach i.e., the actions of target audiences and the factors that influence them. It encompasses Outcome Levels 3 and 2. Target audiences are the individuals and populations that a Stormwater Management Program is directed to, usually the people responsible for source contributions, but sometimes also others who play a supporting role in bringing about desired changes (industry associations, hotline callers, schoolchildren, etc.). Because source reductions can only be achieved by the people responsible for loadings, a successful program will be one that is able to induce positive behavioral changes in key target audiences. **Table 2.2** provides examples of a variety of specific target audiences.

As will be further explored in **Section 5.0**, source types and target audiences can both be extensively subdivided into more specific categories than those shown here.

Level 3 Outcomes address the actions of target audiences, and whether or not changes are occurring in them over time. A wide variety of behaviors may be addressed, and these can be broadly grouped into three types. Examples of each are provided in **Table 2.3**.

Table 2.2: Major Source Categories and Examples of Associated Target Audiences

Municipal Sources	Residential Sources	Industrial/ Commercial Sources	Construction & Development Sources
• Road workers • Maintenance staff • Supervisors / managers • Contractors • Municipal employees	• Homeowners • Renters • Homeowners associations • Dog owners • Auto enthusiasts • Home gardeners • Schoolchildren	• Owners • Operators • Employees • Industry associations	• Developers • Engineers • Planning groups • Contractors • Skilled workers • Laborers

Table 2.3: Major Categories and Examples of Target Audience Actions

Pollutant-generating activities (PGAs)	
• Spills during materials loading and unloading • Releases of fluids during vehicle and equipment repair • Pressure washing without containment	• Overwatering • Improper pet waste disposal • Improper management of food grease
Best management practices (BMPs)	
• Integrated pest management (IPM) practices • Materials substitution	• Smart irrigation controls • Low Impact Development (LID) practices • Structural treatment controls
Supporting behaviors	
• Information seeking • Pollution reporting	• Participation and involvement • Administrative and procedural behaviors

Pollutant-generating Activities (PGAs) are the behaviors that contribute pollutants to runoff (i.e., rinsing off a sidewalk or other surface with material such as sediment, trash, or vegetation on it). Their reduction or elimination is the primary focus of stormwater management programs. PGAs are not necessarily the result of current human behaviors, they may also include pollutant-generating features that may be the result of past behaviors (e.g., erosion from past road design and construction). For simplicity, the term

PGA will be used to describe both the existing features and current activities in a watershed that generate pollutants.

Best Management Practices (BMPs) are activities or other controls that are implemented to reduce or eliminate discharges of pollutants and flow. BMPs can take a variety of forms (source controls, treatment controls, prevention, infiltration, etc.), all of which may be considered as potential alternatives to PGAs. In fact, substitution of BMPs for PGAs can be a key measure of program success. BMPs are the most obvious facet of Level 3 success, but there's also value in understanding other “supporting” behaviors that can help to bring about BMP implementation.

Supporting Behaviors include a wide range of potential actions that are distinct from BMP implementation, but that help to form a bridge toward it. Examples include joining a watershed organization, calling a stormwater hotline, conducting employee training, or developing a Stormwater Pollution Prevention Plan (SWPPP). All of these actions are likely to facilitate the implementation of BMPs by target audiences.

2 Barriers & Bridges to Action

Level 2 outcomes are critical because they form the basis for achieving desired behavioral changes and provide a means of gauging progress toward their achievement. A myriad of factors affect the behavioral patterns of target audiences. Collectively, these are called **influencing factors**, but depending on whether a factor aids in or inhibits a desired behavior, it can be considered either a **barrier** or a **bridge** to action. In practice, the two are not completely distinct. For example, knowledge might be considered a barrier when levels are low, but a bridge when levels are high enough to positively affect a behavior.

For a Stormwater Management Program to effectively influence or change the behaviors of target audiences, these factors must first be explored. **Figure 2.4** provides a simple representation of the role of Level 2 outcomes in mediating the conversion of PGAs to BMPs. As shown, the knowledge and awareness of target audiences constitute the first critical consideration in establishing a path toward correct behaviors. People won’t act differently unless they first understand the problem, and then are motivated and able to change. Studies indicate that education alone is not always an effective driver of behavioral change. Conventional marketing-based educational approaches can be effective in creating public awareness and understanding, but are limited in their ability to foster behavioral change. Because of this, it's also important to consider the many other determinants that potentially exist for any given behavior. Examples include attitudes, costs, commitment, social norms, incentives, convenience, and perceptions of responsibility or accountability.

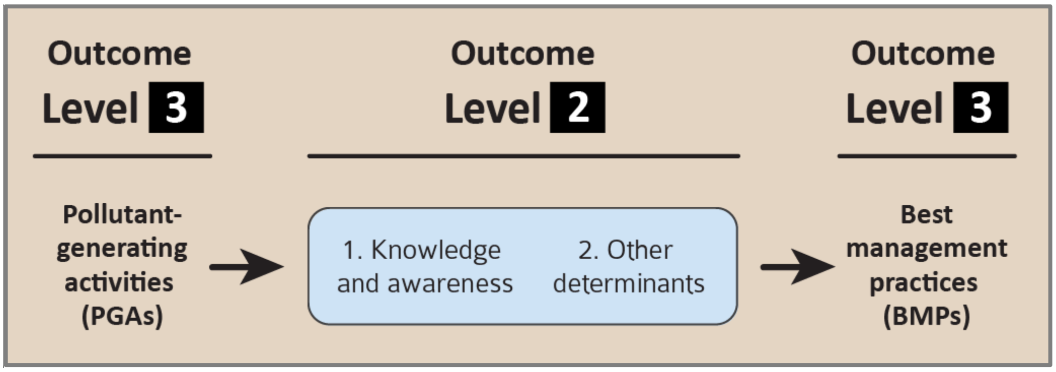
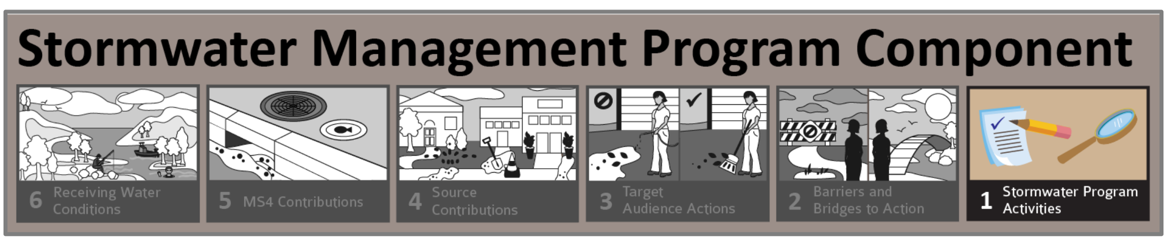
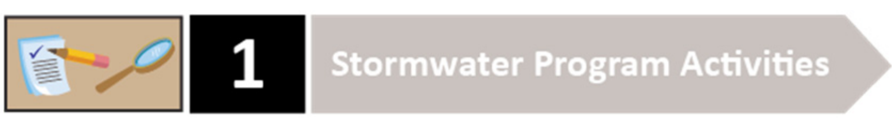


Figure 2.4: The Relationship of Influencing Factors to PGAs and BMPs

In recent years, many stormwater programs have invested extensively in the study of influencing factors. As managers increasingly understand the role of specific barriers and bridges in influencing targeted behaviors, they should become increasingly effective in achieving them.



The **Stormwater Management Program Component** focuses on the various activities that are conducted within a program.



Examples of Level 1 activities that are measured include providing education to residents, inspecting businesses, surveying target audiences, and conducting receiving water monitoring. As described below, it's useful to divide Level 1 activities into four types.

- **Facilitation activities** are those which bring about (or "facilitate") changes in target audiences. For example, a program manager seeking to increase BMP implementation by construction site workers might rely on facilitation activities such as training and inspections. Conversely, a residential program element might be focused on education, incentives, and waste collection to encourage pesticide use reduction or picking up after pets. Managers typically find themselves seeking to bring about the broad-scale implementation of controls by regulated parties and other target audiences, more often than not, with limited control over the outcomes themselves. Because the success of a program is almost always determined by its ability to influence change in others, the selection of facilitation measures is one of the most critical decision points in the design and implementation of a control strategy.

- **Direct Implementation of Treatment Control BMPs** by the MS4 program is another important type of implementation activity. Given the increasingly stringent performance expectations put on MS4 programs in recent years, both for permit and TMDL requirements, emphasis on the direct implementation of structural treatment controls has also increased. Many programs are also now planning and funding the construction and maintenance of regional or sub-regional treatment control BMPs. These BMPs can be a critical part of a successful implementation strategy.

- **Administrative activities** support the operation or management of the stormwater program. Unlike facilitation activities, they focus on the operation of the program itself rather than its relationship to other outcome types. Typical examples include reviewing and updating source inventories and program documentation such as policies or procedures.

- **Data collection and analysis activities** provide the feedback necessary to plan and evaluate outcomes. Their primary purpose is to provide managers with the data and information they need to assess conditions, evaluate change, and determine whether specific outcomes are being achieved. Feedback is necessary for the evaluation of all outcome types. Data collection and analysis activities are an essential part of a program's assessment strategy.

While there is a tendency to think of Level 1 outcomes as “bean counting,” they are essential for bringing about changes at higher outcome levels and for providing the feedback necessary to evaluate success. It does managers little good to know that key changes are occurring if they don't understand what’s driving them or where adjustments can be made to repeat or optimize results. It's not always necessary to report out on all Level 1 outcomes in detail, but it is crucial that managers understand what is being implemented, what data are necessary to track these activities, and where modifications should be made in the future.

This page intentionally left blank

Section 3.0 Introduction to Strategic Planning for Stormwater Management Programs

*This section applies the concepts and principles described in **Section 2.0** to the development of a **Stormwater Strategic Plan** that will guide the development and implementation of specific stormwater management plans and programs, and establish a basis for evaluating and updating them. Strategic planning for stormwater managers is best thought of as "strategic problem solving." Managers will identify and prioritize the problems to be addressed by their programs and develop strategies for resolving them. As a part of this process, managers will consider each of the six outcome levels introduced in **Section 2.0**. The general planning process described in this section will provide a basis for the more detailed guidance described in **Sections 4.0** through **7.0**.*

3.1 Background

Stormwater program management can be broadly divided into three phases of activity (**Figure 3.1**):

1. Program planning and modification;
2. Program implementation; and
3. Effectiveness assessment.
4. During the program planning phase, implementation and assessment results will be reviewed to identify necessary changes or refinements for future implementation. These modifications can then be made and the next round of implementation initiated, leading again to renewed assessment and planning.

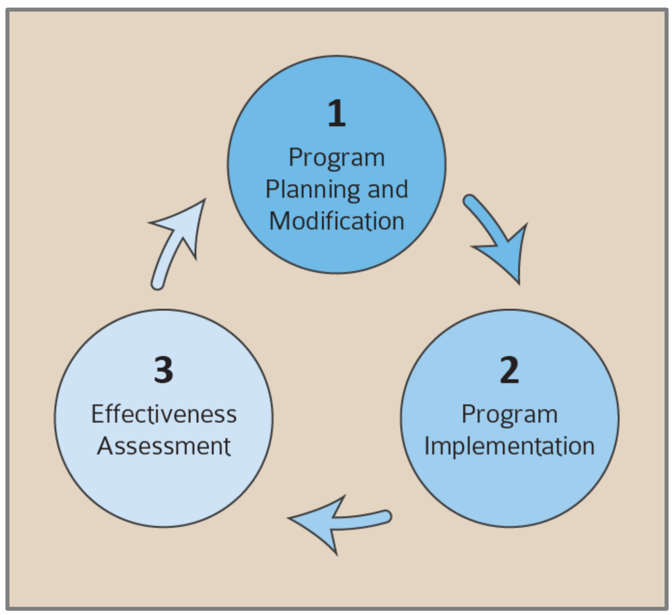


Figure 3.1: The Iterative Program Management Cycle

Over time, the repeated application of this process – each phase continuously informing the next – should result in the improvement of stormwater programs and the achievement of the desired results that they are designed to achieve. Most of the specific guidance provided in this document focuses on program planning with the understanding that this is where the details of implementation and effectiveness assessment strategies will be considered and incorporated.

This section describes the development of a **Stormwater Strategic Plan** (**SSP**). During this process, managers will identify goals for what will be achieved by the stormwater management program and the strategies necessary to support their attainment. Strategic planning is particularly important to the eventual success of a program because it's during this process that problem conditions are defined, goals are set, and the measures established that will later be tracked and evaluated.

A **Stormwater Strategic Plan** (**SSP**) helps guide the development and modification of a **Stormwater Management Plan** (**SWMP**). The purpose of the SSP is to systematically explore and define the strategies that will be considered and incorporated as a part of a SWMP, and to suggest how program managers might choose some options over others. In essence, SSP development is the process by which the strategic approach and content of a SWMP is developed.

Most municipal stormwater permits require the development of detailed management plans to guide the implementation and evaluation of stormwater programs. These plans can take on a variety of names and forms [Urban Runoff Management Plan (URMP), Drainage Area Management Plan (DAMP), Stormwater Management Plan (SWMP), etc.]. For the purposes of this document, they are collectively referred to as SWMPs. In some cases, a SWMP provides an overarching framework that is both strategic and operational. In others, it is accompanied by additional, more detailed operational plans which describe the programs, activities, policies, or procedures necessary to carry out higher level strategies. There is no standard division of content between strategic and operational plans, so the specific content of each must be determined on a case-by-case basis. Operational plans are not addressed further in this guidance.

Regardless of the specific form and content that a SWMP takes, the purpose of the SSP is to ensure that the SWMP is strategic and adaptive. In some cases, a SSP may be equivalent to, or part of, a SWMP. In others, it may constitute a separate planning process that informs SWMP development.

Development of a Strategic Strategic Plan is divided into three distinct stages.

- Starting with **Planning Preparation (Stage 1)** managers will establish the basic organizational framework necessary to compartmentalize and make sense of the detailed planning tasks that follow (**Section 3.2**).

- During **Strategic Planning (Stage 2)**, managers will identify and prioritize problems to be addressed, identify specific goals for resolving them, and identify program activities needed to drive and evaluate these changes[1] (**Section 3.3**).
- **Strategic Plan Completion (Stage 3)** will provide a roadmap to guide program implementation and evaluation (**Section 3.4**).

Completing this comprehensive process will often require that a wide range of data and information be considered, sometimes exceeding explicit regulatory requirements. The purpose of this process is not to create additional requirements, rather it is designed to help managers more effectively and efficiently meet existing ones.

3.2 Planning Preparation (Stage 1)

Before Strategic Plan development commences, some upfront steps should be completed.

Step 1 Establishing the Strategic Plan Framework

The Strategic Plan Framework addresses two essential sets of issues; scope and content, and organizational structure (see **Tables 3.1** and **3.2**). Given the numerous factors to be considered and their many potential interrelationships, initial assumptions regarding scope, content, and organization will need to be periodically reviewed and updated.

- **Scope and Content -- What should the Strategic Plan contain?**

As described in **Table 3.1**, several factors influence the general content of the Strategic Plan. Without exception, managers will first have to establish applicable geographic and temporal scales for the Strategic Plan and its major elements. Likewise, other factors such as regulatory requirements (usually MS4 permits or TMDLs), existing commitments, and media considerations can influence how specific goals are ultimately carried out.

[1] **Section 3.3** will introduce and explain this process, while additional detailed guidance on its application at each of the six Outcome Levels will be provided in **Sections 4.0 (Source and Impact Strategies), 5.0 (Target Audience Strategies),** and **6.0 (Program Implementation Strategies)**.

Table 3.1: Factors Influencing Strategic Plan Scope and Content

Geographic area. All program goals and activities will apply within defined geographic boundaries. Most Phase I MS4 permit requirements apply jurisdictionally, but some activities are coordinated permit-wide or by watershed. Watershed requirements are increasingly being emphasized to direct resources toward priority receiving water impacts. Municipal stormwater permits often include requirements at multiple scales.

Timeframe. Every management initiative is bounded by one or more applicable timeframe. MS4 permits are issued on 5-year cycles, but implementation timeframes vary. Most outcomes are assessed annually, but some may take decades. Plans should reflect the timeframes necessary to achieve and assess all priority outcomes.

Regulatory considerations. MS4 permits and TMDLs establish performance standards, mandatory program content, and minimum activity requirements (e.g., required inspection frequencies). Other regulatory requirements (CEQA, 401 permits / 404 certifications, Endangered Species Act, etc.) can create constraints or limitations on how these directives can be carried out. An early review of applicable requirements can be useful in setting plan scope and in identifying potential conflicts.

Existing programs and activities. Program planning rarely starts from scratch. Many programs already have ongoing stormwater elements in place; others (used oil recycling, street sweeping, food inspections, etc.) may support stormwater management goals. Even when permit requirements are new, accumulated experience and existing resource commitments can be useful in meeting them.

Media and pathway considerations. Stormwater programs emphasize the impacts of surface runoff on receiving water bodies. Many impacts, though, can be related to other sources and migration pathways (e.g., metals from air emissions or nutrients through groundwater seeps). Sources and pathways that are not immediately within the required scope of a MS4 program should still be considered during planning. In some cases they can help to strengthen management approaches. In others they may help to delineate what is outside the ability or responsibility of a program to control, or define the limit of targeted receiving water quality improvements.

- **Organizational Structure -- How should Strategic Plan content be arranged?**

Organizational structure will determine how individual tasks are compartmentalized and provide a scheme for consolidating and interpreting results. **Table 3.2** lists and provides examples of parameters to consider in establishing this structure. Every Strategic Plan will be unique, but will incorporate each of these parameters to varying degrees. At this stage, organizational structure can only be worked out at a fairly high level, i.e., in no more detail than the identification of sources and/or target audiences. As additional details emerge, this structure will continue to be updated. Two of the parameters – source type and constituent priorities – should be the highest level organizing principles in a Strategic Plan. These will further explored in **Section 4.0**.

Step 2 Compiling Data and Information

In Step 2, managers will gather the data and information needed for strategic planning. Given the range of goals and outcomes potentially under consideration, many sources of data and information are possible (see **Table 3.3**). Since it's not possible to fully anticipate data and information needs up front, managers will need to periodically check back to this step again throughout the strategic planning process.

Data needs will vary according to outcome type, analytical objectives, and program goals. Managers should consider all reasonably available sources, although practical limitations such as relevance, applicability, availability, and cost must be considered. Precedence will normally be given to data that are local and specific to an immediate task or objective.

Table 3.2: Factors Influencing Strategic Plan Organizational Structure

Source Components (or Types)

- New development / redevelopment projects
- Construction sites
- Residential areas
- Municipal sources (streets, parks, fleet maintenance facilities, etc.)
- Industrial and commercial sources (restaurants, auto maintenance, etc.)

*See **Section 4.4** and **Attachment A** for additional discussion of source types.*

Potential Priority Constituents

- Bacteria
- Sediment
- Nutrients
- Metals
- Pesticides
- Trash
- PAHs

Numerous constituents can emerge individually or in combination as management priorities.
*See **Section 4.2** and **Attachment B** for additional discussion of priority constituents.*

Target Audiences

- Residents
- Schoolchildren
- Dog / horse owners
- Developers / project proponents
- Contractors / site workers
- Business operators / employees
- Municipal employees (road crews, maintenance staff, etc.)

Target audiences are the populations responsible for specific source contributions. Since most program activities are directed to them, it's essential that they be clearly delineated.

Target Audience Actions

Pollutant-generating activities (PGAs)

- Spills during materials loading and unloading
- Releases of fluids during vehicle and equipment repair
- Overwatering
- Improper pet waste disposal
- Improper management of food grease

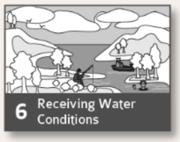
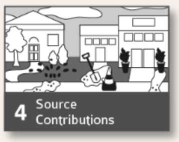
PGAs are the behaviors that contribute pollutants to runoff. Their reduction or elimination is the primary focus of stormwater management programs.

Best management practices (BMPs)

- Integrated pest management (IPM) practices
- Materials substitution
- Smart irrigation controls
- Low Impact Development (LID) practices
- Structural treatment controls

BMPs are the opposite of PGAs. Because they reduce or eliminate pollutant discharges to runoff, substitution of BMPs for PGAs is a key measure of program success.

Table 3.3 Potential Inputs for Strategic Planning

Outcome Level	Examples of Data and Information Resources
 	☑ Receiving water and MS4 monitoring programs ☑ Regulatory agencies and research institutions (SCCWRP, WERF, etc.) ☑ Online repositories, directories, and databases (CERES, SWAMP, etc.) ☑ Published or unpublished research, literature, and technical reports ☑ Special investigations ☑ MS4 maintenance inspections
	☑ Facility or site inspections, monitoring, development plans, etc. ☑ Published research, literature, and technical reports ☑ BMP performance studies ☑ Third party submission of monitoring data ☑ Special studies and investigations ☑ Published or unpublished research, literature, and technical reports
 	☑ Interviews, surveys, tests, and quizzes ☑ Facility or site inspections ☑ Third party submission of compliance data ☑ Special investigations ☑ Published or unpublished research, literature, and technical reports (community-based social marketing studies, etc.)
	☑ Annual compliance reports, source inventories and databases, etc. ☑ Completed effectiveness assessments

3.3 Strategic Planning (Stage 2)

Figure 3.2 illustrates the core elements of a comprehensive strategic planning process for stormwater management programs. **Figure 3.3** lays out the entire process from beginning to end and identifies the sections of this document in which individual planning elements are addressed in greater detail. To complete the process, the core steps shown in **Figure 3.2** must first be completed in "reverse order," beginning with Level 6 and working "backward" one outcome at a time toward Level 2. Results will then provide a basis for conducting the Outcome Level 1 planning steps introduced at the bottom of **Figure 3.3** and described further in **Section 6.0**. This process will apply in its entirety regardless of the choices made about content and structure during Planning Preparation (Stage 1).

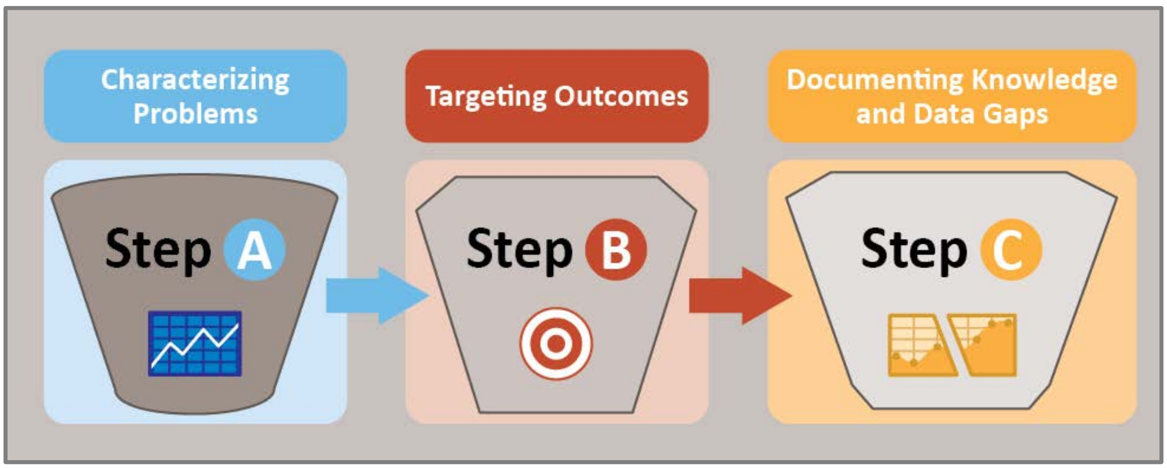


Figure 3.2: Core Strategic Planning Steps (applies to Outcome Levels 2 through 6)

Strategic planning is treated as a "problem solving exercise" focusing initially on identifying and prioritizing problems and then developing strategies for addressing them.

- In **Step A**, existing conditions (or outcomes) are evaluated, first very broadly and then in detail, to determine which of them constitute problems potentially requiring a management response.
- In **Step B** priority problem conditions are reviewed to determine the types of changes that will be sought and to establish timelines for achieving them.
- Another important consideration throughout the planning process is the need to continually identify and document knowledge and data deficits (**Step C**). While this is shown as a discrete step in **Figure 3.2**, it's actually an integral part of the entire planning process. Planning and assessment are often hindered by limitations on data and information availability.

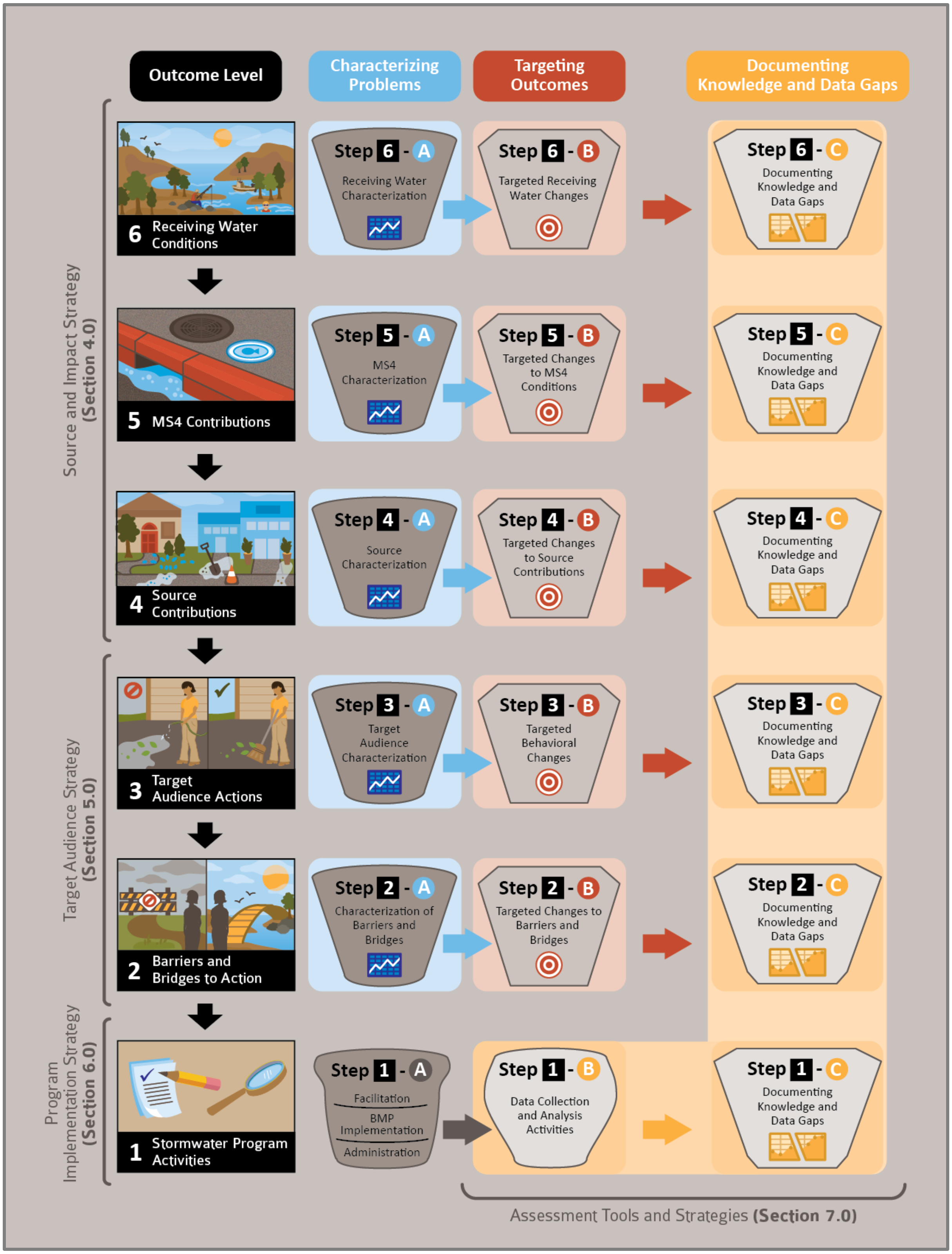
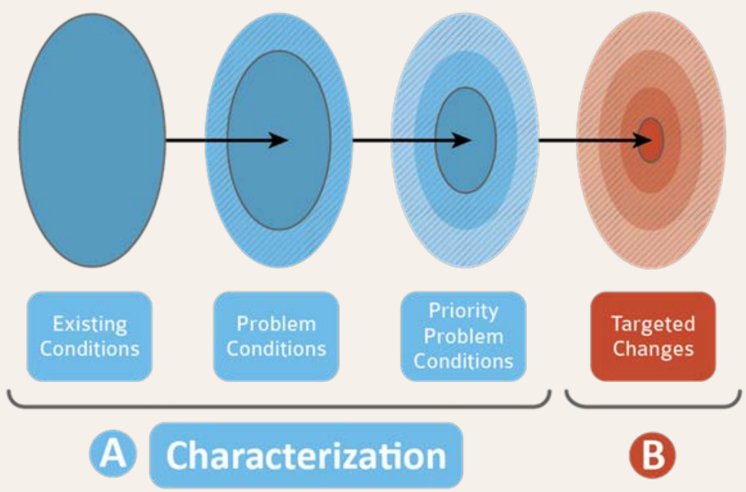


Figure 3.3: Strategic Planning Process Overview

Key Concept 3.1 Prioritization is Essential to Strategic Planning

Prioritization occurs throughout the strategic planning process. Because results are often initially broad and inclusive, a wide range of conditions might seem to be important. In practice, managers are limited by the resources they can bring to bear on any potential problem. Prioritization allows a progressive "narrowing" of results so that they can focus on what's most important. To illustrate, the solid portion of each oval below represents the relative number of potential conditions at various stages of the planning process. As shown, the number of conditions decreases in each successive phase.



Not every measurable condition represents a problem, and not all problems are of equal importance. Managers will need to focus on conditions representing the highest priorities for potential action (See **Step A, Characterizing Problems**). Some of these will likely be targeted for change, and others deferred for future consideration (See **Step B, Targeting Outcomes**).

To resolve uncertainty over time, data and information needs must continually be documented and addressed. This is central to the iterative "hypothesis testing" nature of stormwater management. In practice, a one-size-fits-all approach to strategic planning isn't possible. Results will reflect individual priorities, data availability, and methodological choices and limitations. Managers may sometimes find it challenging to follow this process in a simple linear fashion. However, because each step sequentially informs the next, they should be followed in the order presented below wherever possible. If individual steps are initially glossed over or skipped, they should be returned to as results accumulate or as new insights emerge.

Step A Characterizing Problems

During characterization, managers explore what is known about existing conditions at all outcome levels, determine which of them constitute problems, and develop priorities for the changes to be sought through program implementation. This work is divided into three tasks as shown in **Figure 3.4** and described below.

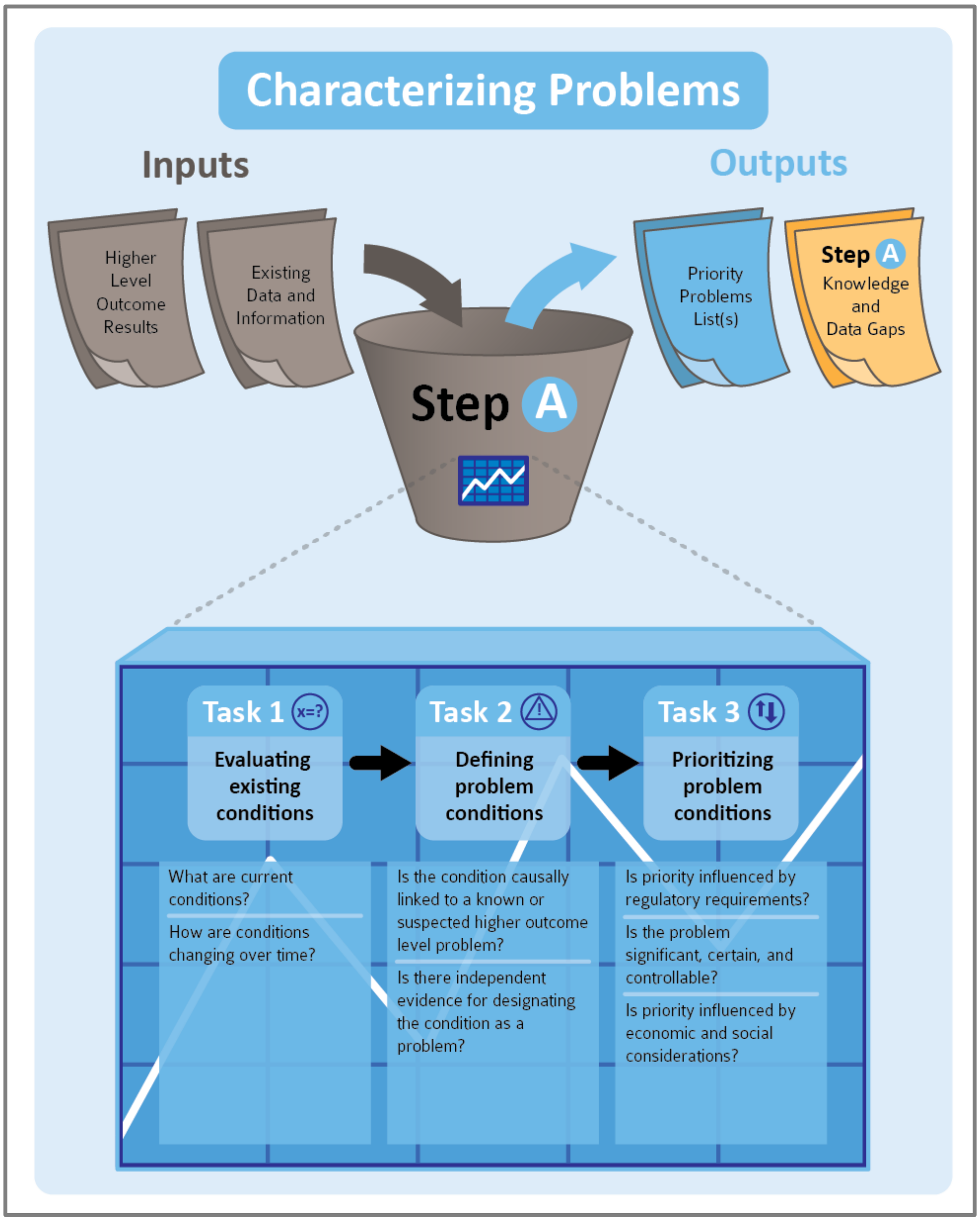


Figure 3.4: General Process for Characterizing Problems

Task 1 Evaluating Existing Conditions

The primary purpose of this task is to establish the factual basis needed for subsequent planning tasks. Available data and information will initially be reviewed to determine what is known at each applicable outcome level. As described above in **Planning Preparation (Section 3.2, Step 2)**, different data sources (monitoring results, source inventories, surveys, etc.) will apply depending on the condition under consideration. This fact-gathering exercise addresses two types of questions.

Step A Task 1 Key Questions
Evaluating Existing Conditions

Inputs	Key Questions	Outputs
Available Data, Information, and Results	**Question 1:** What are current conditions? **Question 2:** How are conditions changing over time?	**Existing Conditions**

Question 1 What are current conditions?

Current conditions provide a snapshot of how things look, either at the time of measurement or generalized over a defined period (a reporting year, the wet season, etc.). They describe only what is known about a particular condition (or set of conditions) rather than extrapolating beyond the data at hand. For example, what is the upper 90th percentile concentration of nitrates in the lower San Diego River during dry weather? Or how well do construction workers understand the proper application of a silt fence? Or how do bacteria levels vary across a defined group of MS4 outfalls? Current conditions describe what we know and establish the measurability that will later be needed for interpretation of change and success in meeting established goals.

Several parameters should be considered in characterizing conditions. The **nature** of the condition refers to its general characteristics or attributes, and **magnitude** describes its dimension or scale. Together, nature and magnitude provide a basic description of each condition, but it's also important to consider how they vary in time and space. **Variability** refers to how spread apart the measurements in a distribution are, or how they vary from each other temporally or spatially. **Temporal variability** describes how often or frequently the condition occurs or how it varies over time, whereas **spatial variability** describes its physical patterns of dispersal (within a population, receiving water, etc.).

A wide range of descriptive statistics can be used to describe current conditions. These include, but are not limited to, yes/no determinations, single values, simple counts, central tendency (mean, median, etc.), measures of spatial variability, and confidence intervals. Several descriptive statistics can also be used together to provide a more comprehensive understanding of existing conditions. Managers should be extremely cautious about using single or average values alone to describe outcomes above Level 1. For strategic planning and assessment, analytical focus is normally on populations of outcomes rather than single ones, and variability within these populations can have important implications for program design. Variability refers to refers to how spread apart the measurements in a distribution are, or how they vary from each other temporally or spatially.

Figure 3.5 illustrates a standard normal distribution that might apply to almost any outcome, for example numbers of dog owners on the y-axis and the frequency of BMP implementation on the x-axis. In this simple example, BMP implementation by low performers would be represented on the left tail, high performers on the right, and everyone else in between.

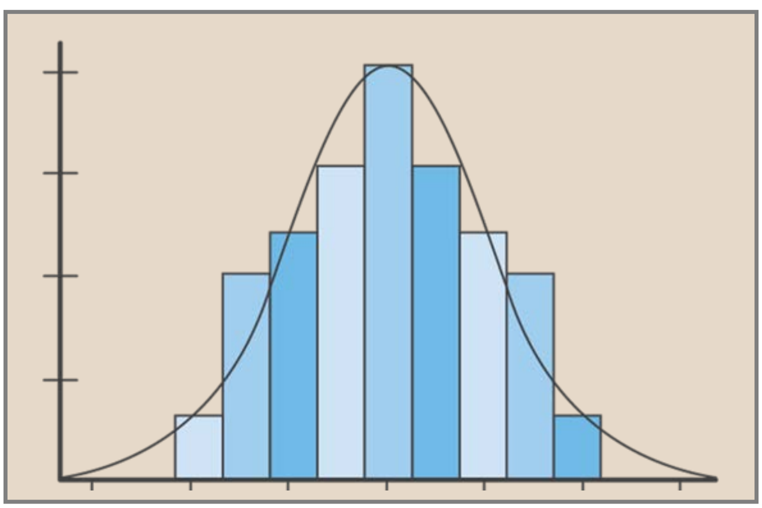


Figure 3.5: A Normally Distributed Population of Outcomes

As will be described later, there are important reasons for considering not only the differences in the characteristics of these sub-populations, but also the area under the curve represented by each. **Section 7.0** provides a more detailed discussion of potential data analysis tools and approaches.

Question 2 How are conditions changing over time?

It's easy to think of an existing condition as a single measure captured at one point in time. To use one of the examples mentioned under Question 1, the upper 90th percentile concentration of nitrates in the lower San Diego River on April 13, 2004 is measured as 9.2 parts per million. Since most measurable conditions are normally not static, it would be unrealistic to assume that the same value would be obtained if we sampled again in a week, a month, or a year. So it's important to understand if and how conditions are changing. **Trends** are increases, decreases, or other discernable changes in the magnitude, prevalence, or distribution of a condition over time. Trend estimation can be used to make and justify statements about tendencies in outcomes, such as nitrate concentration, by relating their measurement to the times at which they occur. The general goal of trend analysis is to look at data over time to understand whether and how changes are occurring (e.g., how have nitrate concentrations changed over the past 10 years? Or is the distribution of exceedances in the MS4 increasing or decreasing over time?).

Managers are often interested in knowing whether a parameter is increasing or decreasing over time. A range of approaches are available for doing so. The simplest is to fit a straight line with the outcome data plotted vertically and time plotted horizontally, however other options such as a least-squares fit are also frequently utilized. **Figure 3.6** provides an example of a trend analysis for turbidity in the Sweetwater and Tijuana Rivers. Trend analysis can be a very powerful tool for interpreting a wide variety of outcomes.

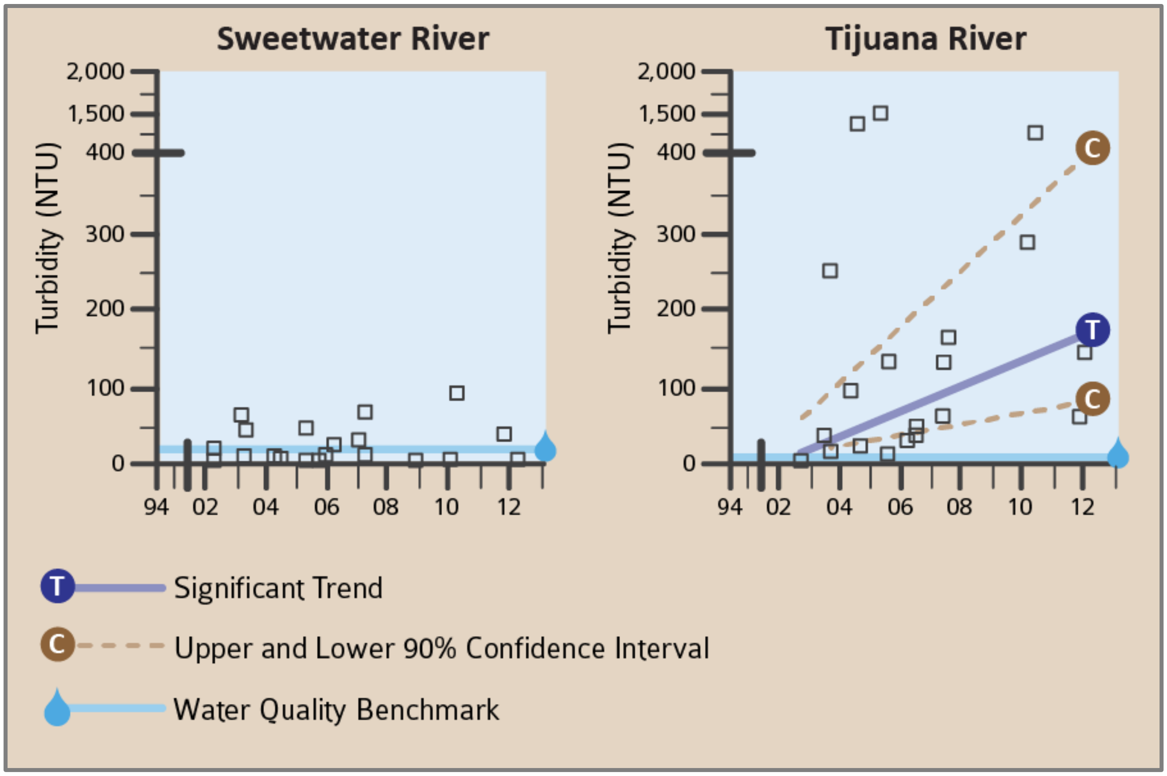


Figure 3.6: Example of Trend Analysis

The primary output of **Task 1** is the documentation of a range of existing conditions. A second important output will be the identification of knowledge and data gaps associated with **Task 1** completion. These gaps are discussed further under **Step C** below. Since there are no specific limits on the scope of Task 1 results, they can be very broad. **Task 2** below will focus on narrowing the range of conditions to those which represent problems. Discretion will be needed in determining how many conditions can be further considered – this requires that managers estimate the resources needed to address targeted problems, and limit the number that can be evaluated within these limitations.

Figure 3.7 provides a Review Checklist to guide managers through Task 1 completion. **Table 3.4** adapts both **Task 1** questions individually to Outcome Levels 2 through 6. These more specific questions form the basis of the guidance provided in **Sections 4.0** and **5.0**.

Task 2 Defining Problem Conditions

A problem condition can be thought of as the difference between how something is now and how we would like it to be in the future. In practice, such differences are usually not obvious or easily discerned, so it will take some additional effort to decide which of the broad range of existing conditions identified in **Task 1** should be treated as "problem conditions”. In contrast to the evaluation of existing conditions, the determination of problem conditions will often be highly interpretive.

It's not unusual for managers to equate problem conditions with receiving water impacts. However, for problem definition to be useful in program planning, managers must adopt a broader definition that includes measurable conditions at all levels between 6 and 2. That is, any condition that has a direct or an indirect role in causing a receiving water impact must be considered as part of the problem definition equation. In evaluating the problem potential of any identified condition, two lines of questioning are helpful.

Step A Task 2 Key Questions
Defining Problem Conditions

Inputs	Key Questions	Outputs
Existing Conditions	**Question 1:** Is the condition causally linked to a known or suspected higher outcome level problem? **Question 2:** Is there independent evidence for designating the condition as a problem?	**Problem Conditions**

Review Checklist

Step A Task 1
Evaluating Existing Conditions

Apply this task very broadly across Outcome Levels 6 through 2, one at a time. The purpose is to provide a "snapshot" of what is currently known at each Outcome Level.

✓ **Compile existing data, information, and results applicable to the Outcome Level. Consider the following questions:**

Question 1: What are current conditions?

Consider nature, magnitude, and temporal and spatial variability.

Question 2: How are conditions changing over time?

✓ **Consolidate results into one or more summary lists of existing conditions. Categorize results as determined appropriate (by condition type, etc.).**

✓ **Compile supporting documentation for listed conditions.**

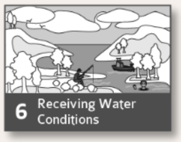
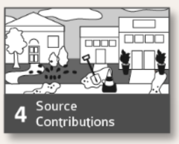
✓ **Select the conditions in the summary list(s) that will be further evaluated as potential problems in Task 2. Consider "back-up" lists for future evaluation as necessary.**

✓ **Document the critical data and information gaps identified during Task 1 completion.**

NOTES

Figure 3.7: Review Checklist for Evaluating Existing Conditions

Table 3.4: Outcome-specific Questions Guiding Evaluation of Existing Conditions

	Question 1. What are current conditions?	Question 2. How are conditions changing over time?
 See Section 4.2	• What are current receiving water conditions?	• How are receiving water conditions changing over time?
 See Section 4.3	• What are current MS4 conditions?	• How are MS4 conditions changing over time?
 See Section 4.4	• Which drainage areas contribute pollutants and flows to MS4s? • Which sources contribute pollutants and flows to the MS4? • What are the current flow and pollutant contributions of drainage areas and sources?	• How are drainage area and source contributions changing over time?
 See Section 5.2	• Which target audiences are associated with priority source contributions? • What are the behavioral patterns of target audiences? • What are the characteristics of target audiences?	• How are behaviors changing over time?
 See Section 5.3	• What factors influence priority target audience behaviors?	• How are influencing factors changing over time?

The first question follows the general supposition employed throughout this document that linkages exist between individual outcomes. In particular, that the existence of a problem condition at any given level implies the existence of at least one "causal" problem condition at the next lower outcome level. In theory, problem statements are strongest when they reflect such a linkage, and pending the resolution of Question 2, may be discarded if not proved relevant.

The second question acknowledges the practical reality that these linkages are difficult to establish, and that problem conditions must therefore often be identified through other "independent" lines of evidence. In both cases, experience and judgment play a critical role.

Question 1 Is the condition causally linked to a known or suspected higher outcome level problem?

Throughout strategic planning, analysis will build on the results obtained at each previous outcome level (Level 3 will be informed by 4, 2 informed by 3, etc.). When an individual problem condition is known or suspected, managers should look to other outcomes at the next lowest level as potentially causing or contributing to it. When these linkages are established, the "causative" conditions will also be implicated as problems (see **Key Concept 3.3**).

Consider the case of a MS4 outfall discharge with average chronic copper concentrations of 5.2 µg/L (Level 5). The outfall is known to discharge to a receiving water with demonstrated exceedances of water quality standards for copper (an outcome level 6 problem). Because of its implicit causal relationship to the receiving water problem, the outfall discharge might reasonably be concluded to represent a "linked" problem condition. To use a completely different example, a “low” level of knowledge regarding a pollutant-generating activity in residents (e.g., overwatering) could be considered a problem because it contributes to an overwatering behavior. In both examples, we’re less concerned about the actual magnitude of the lower level condition than the fact that it’s potentially contributing to a problem condition at the higher level.

Where linkages between outcomes are suspected, managers should focus on confirming or strengthening them over time. One approach is to "experiment" through targeted implementation. In this case, a change in a measured outcome (e.g., levels of a targeted behavior) might be targeted with a goal of testing the hypothesis that a resultant change will occur in the higher level outcome (i.e., the "dependent condition"). For example, a hypothesis that power washing practices contribute to dry weather discharges in a given area could be tested by implementing a program of control measures directed at power washers. By tracking outcomes at both levels, measurements can be used to experimentally demonstrate a linkage between two separate problem conditions. This is a typical approach for pilot projects, but it can also be part of normal program implementation when data collection approaches are designed to explore linkages (see **Section 7.0**).

Ideally, our understanding of individual problem conditions and the relationships between them will become increasingly certain over time. However, because this may never be the case for many measured conditions (see **Key Concept 3.5**), it's important to consider other lines of evidence.

Question 2 Is there independent evidence for designating the condition as a problem?

Question 1 focused on a situation where previously-established higher level problem conditions provide a point of reference for defining other causally linked problem conditions. As managers work through each outcome level in order, they'll find considerable variability in the degree to which specific problem conditions and the linkages between them are understood. Because this knowledge base is often incomplete, managers will sometimes need to look elsewhere for other frames of reference in interpreting problem conditions. That is, problems will sometimes have to be defined independently of other outcome levels.

Using the example that was just described, the same level of copper is measured at the outfall, but this time there is no evidence that the receiving water is impacted by copper. In considering whether or not the outfall condition might still represent a problem, the manager must now look to other independent evidence. For example, does the discharge itself exceed an established regulatory benchmark? Are copper concentrations outside the norm or higher than at outfalls in other similar drainage areas or land uses? Has experience shown similar levels to be problematic elsewhere?

Clearly there is an even more important role here than in Question 1 for experience and best professional judgment. Managers will need to be thorough in identifying and exhausting available lines of evidence. In many cases, problem designation will be based solely on a judgment that a particular change (e.g., a higher level of understanding) would represent an improvement. Such determinations are made every day by managers for very good reason. Over time, as increased measurability and targeted implementation allow the validation of working assumptions, the types of structured linkages suggested in Question 1 can be further explored.

On completion of problem definition, managers will have a list (or lists) of Outcome Level 2 through 6 problem conditions. This delineation should be considered provisional, and may need to be updated as other planning steps are later completed. Whether or not a particular judgment or hypothesis turns out to be correct can only be determined through ongoing implementation and evaluation. A second important output will be the identification of knowledge and data gaps associated with Task 2 completion. These gaps are discussed further under **Step C**.

Figure 3.8 provides a Review Checklist to guide managers through Task 2 completion. **Table 3.5** shows how Questions 1 and 2 are applied at each outcome level. These questions form the basis of the guidance on problem definition provided in **Sections 4.0** and **5.0**. In some instances managers will find that problem conditions are already known (such as for TMDLs), and may question the need for further evaluation. However, these general approaches may still be useful as a "reality check." It can often turn out that our understanding of problem conditions is less certain than initially thought.

Review Checklist

Step A Task 2

Defining Problem Conditions

At each Outcome Level, apply this task individually to each Task 1 condition selected for further evaluation. The purpose of this task is to determine which of these conditions should be designated as problems.

✓ **For each identified condition, consider the following questions:**

Question 1: Is the condition causally linked to a known or suspected higher outcome level problem? If no, or if unknown, continue to Question 2.

Question 2: Is there independent evidence for designating the condition as a problem?

✓ **Document known or suspected problem conditions for the Outcome Level.**

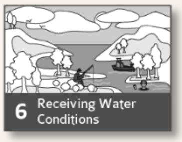
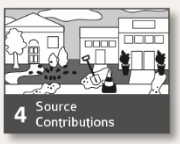
✓ **Consolidate results into one or more summary lists. Categorize results as determined appropriate (by problem type, known versus suspected, etc.).**

✓ **Document all data and information gaps identified during Task 2 completion.**

NOTES

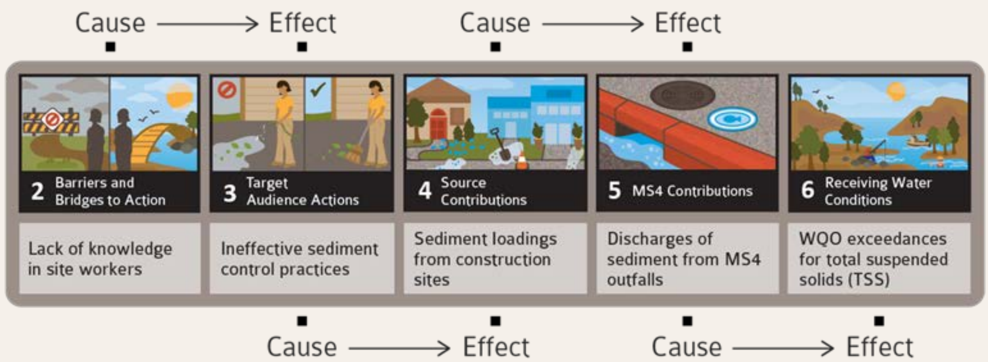
Figure 3.8: Review Checklist for Defining Problem Conditions

Table 3.5: Outcome-specific Questions Guiding Problem Definition

	Question 1. Is the condition causally linked to a known or suspected higher outcome level problem?	Question 2. Is there independent evidence for designating the condition as a problem?
 See Section 4.2	• Does the receiving water condition represent a known or suspected beneficial use impact?	• Is there independent evidence for designating the receiving water condition as a problem?
 See Section 4.3	• Does the MS4 condition contribute to a receiving water impact?	• Is there independent evidence for designating the MS4 condition as a problem?
 See Section 4.4	• Is the drainage area or source contribution causally linked to a known or suspected MS4 or receiving water problem?	• Is there independent evidence for designating the drainage area or source contribution as a problem?
 See Section 5.2	• Is the behavior causally linked to a known or suspected source contribution?	• Is there independent evidence for designating the behavior as a problem?
 See Section 5.3	• Which influencing factors are barriers?	• What is the collective influence of identified barriers?

Key Concept 3.2 Problem conditions are "causally" linked

Section 2.0 introduced a fundamental principle that outcomes are sequentially linked in "chains" of cause-and-effect relationships, with the final element in that progression being receiving water conditions. This relationship is very simply illustrated below.



These linkages are particularly important for the evaluation of problem conditions. If any condition truly represents a problem, it must be assumed to exist both as a cause of at least one "higher level" problem and an effect of one or more "lower level" problems. Outcome Levels 2 (cause only) and 6 (effect only) are exceptions because they represent the ends of the sequence.

In this example, working backward from outcome level 6, the first problem statement (or "effect") is a receiving water impact manifested as persistent exceedances of water quality objectives for total suspended solids (TSS). The immediate cause of this is implicated as discharges of sediment from one or more MS4 outfalls (Level 5) to the receiving water. Each outfall discharge is in turn due to sediment loadings from watershed source, in this case construction sites (Level 4). Since these loadings should not occur if adequate preventive measures were in place, ineffective sediment control practices (Level 3) are also implicated as a cause. Likewise, the fact that site workers are engaging in pollutant-generating rather than best management practices indicates the existence of one or more barriers to correct action (Level 2).

As a strategic design consideration, the existence of these linkages implies that the resolution of a problem condition at one outcome level will contribute to the resolution of problem conditions at each higher numbered outcome level.

It should be noted that the example described here is very simple. In practice, managers will encounter a much higher level of complexity (e.g., pollutant sources and their relative contributions may be unknown). Additional issues to be considered in the design and interpretation of linked approaches are described in **Key Concepts 3.4** and **3.5**.

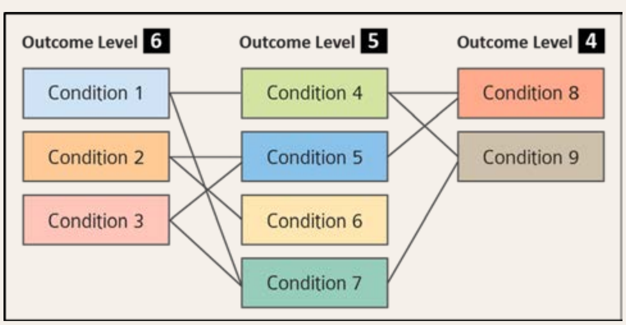
Key Concept 3.3 Relationships between conditions resemble webs more than chains

Key Concept 3.2 presented a very simple example of sequential linkages between single problem conditions. In reality, these might involve any of the scenarios below.

A	B	C	D
Single Problem	Single Problem	Multiple Problems	Multiple Problems
⇩	⇩	⇩	⇩
Single Problem	Multiple Problems	Single Problem	Multiple Problems
(One-to-One)	(One-to-Many)	(Many-to-One)	(Many-to-Many)

Relationships between outcomes in a typical stormwater management scenario are much more likely to exist in complex webs than simple chains. Natural systems are complex and non-linear. However, our models of them are relatively simple, and tend to be linear. For example, a single MS4 discharge might receive contributions from hundreds or thousands of individual sources, varying with time. Or multiple education activities might address the same intended behavioral change in a target audience, and only some of them to any effect. In both cases, it can be difficult to determine how any individual outcome is actually causing an observed effect or a desired change. Moreover, this effect can be multiplied as analysis moves through successive layers of Outcome Levels. While this shouldn't discourage managers from evaluating linkages, it should underscore the need for focusing resources on the highest priority outcomes first.

This document deals almost exclusively with Single-Single relationships (Scenario A), with the understanding that scenarios B, C, and D are more likely to be encountered in the real world. Managers will have to decide how to apply specific methods and approaches to their own unique assessment situations. In doing so, the development of "**outcome maps**" is highly encouraged. As illustrated in the example below, visual representations of the linkages between problem conditions can be extremely valuable.



Whether formally included in program plans, or just conducted as a white board exercise, outcomes mapping can be an essential tool in making sense of the inherent complexity of stormwater management approaches.

Key Concept 3.4 Linkages exist in different stages of certainty

The concept of sequentially linked outcomes is especially salient with respect to the evaluation of problem conditions. As a conceptual basis for planning, understanding relationships between problems is fundamental. In practice, it can be very difficult to do with confidence.

Problem 1	**Hypothesis -- Co-occurrence -- Correlation -- Causation**	**Problem 2**
"cause"	➔ Increasing strength of relationship ➔	**"effect"**

This figure illustrates a continuum in the establishment of linkages between conditions. As shown, relationships are initially often hypothetical or speculative, particularly during the program planning stages. For example, one might ask "if a particular level of mass media coverage (television, radio, etc.) is employed, what level of change in awareness could be expected in a target audience? Hypothesizing is a necessary and central part of the iterative process. Without it, the learning process that drives stormwater management programs would not be possible. But it's also important that relationships between outcomes become increasingly certain over time.

As implementation experience increases and data become more available, relationships can be strengthened. Initially this may involve documenting the co-occurrence of outcomes, i.e., separate outcomes occurring in sequence or within the same period of time.

Co-occurrence is simple to demonstrate (it can be based on single occurrences or samples), but limited in its explanatory value. It does not imply any form of relationship between outcomes, but may form a basis for further exploration.

Correlation is similar to co-occurrence except that it involves some degree of statistical support. Once sufficient sample sizes are established, outcomes can be correlated. This is an important step toward establishing causation since causal relationships must also always be correlative (unfortunately, the reverse is not true). In practice, moving from correlation to causation can be extremely difficult, and will not always be possible.

As outcomes are evaluated, it's important to keep in mind where each relationship is in this continuum. While it may often not be possible to move to a higher level of certainty, it should always be an objective.

Task 3 Prioritizing Problem Conditions

In **Task 2**, managers determined which of the many conditions identified in **Task 1** represent problems. At this point, quite a number of actual or suspected problems may have emerged. Since not all of them will be equally important, additional analysis will help to focus limited resources where they're most needed. Prioritization will allow managers to decide which of the individual problem conditions identified in **Task 2** should be given the highest importance for directed action or additional study. This does not mean that lower priority problems will be ignored, but they may need to be addressed later as time and resources allow.

A general framework for evaluating problem conditions is presented in **Figure 3.9** and described below. Several specific prioritization criteria are introduced, as well as a specific ordering for their consideration that is guided by two questions.

Step A Task 3 Key Questions
Prioritizing Problem Conditions

Inputs	Key Questions	Outputs
Problem Conditions	**Question 1:** What is the priority rating of each problem condition? **Question 2:** What is the relative importance of each problem condition?	**Priority Problem Conditions**

As shown, problem prioritization consists of two primary steps. First a rating must be assigned to each problem condition. Establishing a "value" for each condition provides a basis for differentiating between them. Once ratings have been assigned, they can be reviewed together to determine their relative importance. For each step, managers are encouraged to establish a clear decision-making process up front. The guidance below describes general parameters, but specific details should be determined by the managers conducting the prioritization. In some cases it may be appropriate to utilize professional staff exclusively, while in others a more extended group process may be preferable. Depending on the situation, public participation can be vital to establishing support for proposed priorities. It may often be pragmatic to involve stakeholders or the public during prioritization rather than seeking their approval afterward.

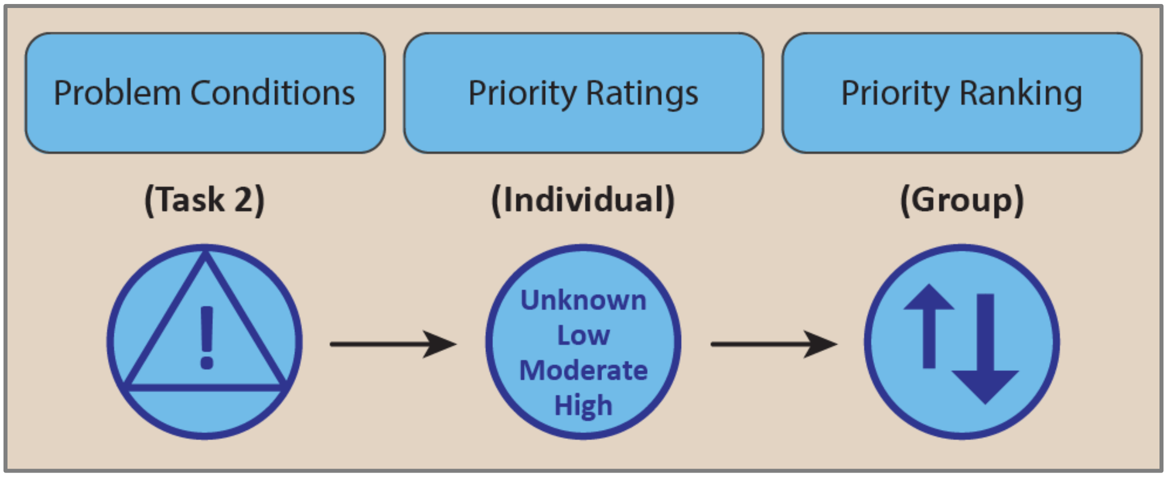


Figure 3.9: General Framework for Prioritizing Problems

Question 1 What is the priority rating of each problem condition?

The establishment of priority ratings entails three successive review tiers. At the conclusion of each, managers can review provisional results and decide whether or not to continue to the next. Given the potentially large numbers of outcomes that might need to be rated in some instances, this can be important in avoiding unnecessary effort. **Regulatory Screening** (Tier 1) is conducted first because these factors often leave little room for discretion or judgment. Where specific priorities are established by permits or other regulatory means, additional review may be unnecessary. During **Technical Review** (Tier 2), managers will take a closer look at the nature of the problem itself. This review is often sufficient to show that a problem is not a priority for action or further investigation. Where a problem still presents as a priority after these first two rounds, managers should continue to the **Sustainability Review** (Tier 3). This review builds on Tier 1 and 2 results by adding in economic and social considerations. As described in **Key Concept 3.5**, this approach follows the principles of sustainability used in a variety of other disciplines.

The rating criteria described here are fairly general, so managers may find that other, more specific criteria better suit their purposes. They may also find that it makes sense to assign specific weightings to particular criteria or to consider them in a different order.

Readers should note **Figures 3.10** through **3.12** below each culminate in the assignment of an overall rating at that respective Tier. The rating designations shown (H, M, L, U, etc.) are for illustration only, and are not intended to imply the use of any particular rating scheme. Managers might just as well use numeric, alphanumeric, or other priority designations, depending on their preferences and needs.

Tier 1 Regulatory Screening

The first objective of the rating process should be to determine the potential influence of regulatory factors. **Figure 3.10** provides an overview of the regulatory screening process.

Figure 3.10: Tier 1 Regulatory Screening[2]

The regulatory drivers most typically influencing or directing priorities will be MS4 permit conditions (e.g., mandated receiving water or source priorities), Total Maximum Daily Loads, and 303(d) listings. Even where priorities are not explicitly mandated, they may later materialize as requirements are interpreted during program implementation or when seeking approval of program approaches from permitting authorities.

While regulatory drivers will often elevate the priority rating of a problem, some can be limiting. For example, compliance with other state and federal laws (e.g., CEQA, 401 permits / 404 certifications, Endangered Species Act, etc.) can create constraints on the details of how or where a program can be directed. Likewise, if a business is already heavily regulated by other existing initiatives (hazardous materials, fire code, etc.) it might simply not warrant the same level of attention as other less regulated source types.

Limitations on the specific statutory responsibility and control of MS4 programs should also be considered. Numerous environmental and water quality problems can exist in areas impacted by urbanization, but not all of them are within the scope or responsibility of a program. Many can or should be addressed under separate discharge permits or other programs. Problems originating from sources that are external to MS4s, or that are separately regulated, may often be excluded as priorities.

[2] S = Strong, M = Moderate, W = Weak, N = None, U = Unknown. These are examples intended to illustrate potential rating designations.

It's important to note the direction of the regulatory influence since some requirements and constraints can affect priority in opposite ways. Likewise, if multiple regulatory factors are identified, their collective influence will need to be considered.

This initial review will provide an early indication of whether or not additional review is needed at Tiers 2 and 3. If a priority rating is clearly established at this point, and there is no ability to modify it, managers may decide to forego additional evaluation and assign an Overall Priority Rating based on the Tier 1 Screening. It's also important to recognize that in some instances regulatory review will indicate priorities that are not supported through the subsequent evaluation of other prioritization criteria. When conflicts arise, there will be no easy way to resolve them. Compliance must be maintained with legal and regulatory obligations, but managers may sometimes also need to advocate for flexibility or regulatory change.

Tier 2 Technical Review

Tier 2 is a technical characterization. It addresses the problem condition itself rather than its relationship to other external factors. This entails a review of three separate types of criteria; significance, certainty, and controllability (**Figure 3.11**).

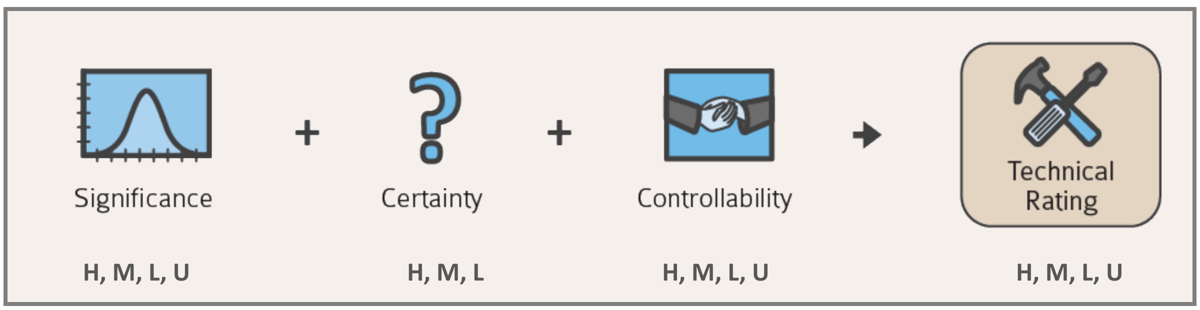


Figure 3.11: Tier 2 Technical Review[3]

Each of these criteria can affect the priority rating independently or in combination, but a problem condition that is significant, certain, and controllable is much more likely to warrant the commitment of program resources than one that is not.

- **Significance** is the importance or meaning of something, in this case a problem condition. Determinations of significance will normally reflect the nature, magnitude, prevalence, and distribution of the condition. Nature describes what a problem is (e.g., elevated bacteria levels, overwatering, etc.), while magnitude, prevalence, and

[3] H = High, M = Moderate, L = Low, U = Unknown. These are examples intended to illustrate potential rating designations.

distribution address its relative severity (e.g., how often, by how much, and where a water quality objective is exceeded). Given the range of potential considerations affecting significance, considerable discretion will be needed in completing this portion of the review.

- **Certainty** refers to the confidence with which a problem condition can be stated. Understanding of problem conditions will often reflect different degrees of certainty. Certainty is a critical consideration because managers will generally not want to expend significant program resources toward a problem that is not well-established. It also gives a general indication of the type of management actions that may be appropriate for a given problem condition (implementation of control measures, continued monitoring, confirmation, etc.). This will be extremely important later as program implementation strategies are selected (**Section 6.0**). Ideally problem conditions will reflect a high level of certainty, but many are likely to be either suspected or unknown (see **Key Concept 3.4**).
- **Controllability** refers to the potential for a program to prevent or eliminate an identified problem condition. A problem that does not have a reasonable chance of being successfully controlled will not likely be a priority for resource commitments. Controllability as a rating factor must address both technical and practical questions. First, do feasible control measures exist or can they be developed to address the problem? And second, what is the ability or responsibility of MS4 programs to conduct or impose available control measures? It will often be the case that technically feasible controls exist to address a particular problem condition, but that they are beyond the ability or scope of a program to reasonably impose. In this respect controllability is often closely related to economic feasibility as described further below.

In practice, managers may be challenged to decide which, if any, of these criteria should be given a higher weighting. In the absence of a specific rationale for doing so, they may want to assume an equal weighting. On completion of the Technical Review, managers will decide whether or not a problem condition should receive further review. In cases where a higher priority rating has been confidently established based on Tier 1 or Tier 2 results, additional analysis may not be needed.

Tier 3 Sustainability Review

The remaining factors described below will provide a practical context for completing the rating process. As shown in **Figure 3.12**, two sets of considerations, economic and social, can be considered together to provide a combined Sustainability Rating. Managers may also elect to develop separate ratings both for economic and social factors; however this example illustrates only the development of a combined rating.

Figure 3.12: Tier 3 Sustainability Review

This review follows closely on the concept of sustainability advocated in various other disciplines (see **Key Concept 3.5**).

- **Economic factors** are essential because every problem has associated costs. Consider the economic burden of beach postings or closures to a coastal city. Ultimately every potential action will also come at a cost that must be balanced with the implications of non-action and the impact to managers' ability to expend resources on other problems. Specific costs may be borne by the MS4 program, target audiences, or society at large. At this stage, analysis will focus on the potential economic impact of the problem condition more so than the costs of potential solutions. Managers' understanding of the latter is likely to be limited during prioritization because specific objectives for change have not yet been established. These costs can be worked out more fully during the establishment of targeted outcomes.

- **Social factors** are those related to society at large or specific segments within it. Perceptions and opinions regarding specific problem conditions, as well as acceptance or resistance to control measures that might be proposed, can be important to prioritization. Although the public may often be unaware of many of the details of a MS4 program, they expect to utilize and enjoy receiving waters, and they play a role in the control measures instituted to protect them. Conversely, problem conditions that are not important to the public may be lesser priorities for resolution.

Overall Priority Rating

As shown in **Figure 3.13**, Tier 1, 2, and 3 results can now be considered together to determine an Overall Priority Rating for each priority problem condition. Each rating will be assigned individually, and has nothing to do with the respective priority of any other condition. Managers must now decide how heavily each of the three sets of results will influence the Overall Priority Rating. Assigning weightings to regulatory, technical, economic, and social factors can be especially challenging given their fundamental differences. Equal weightings are assumed here, but only for illustration. Managers opting to weight individual review factors differently will need to rely on their experience and judgment in doing so. They may also choose to substitute quantitative criteria or methods. However, in most cases qualitative methods are appropriate.

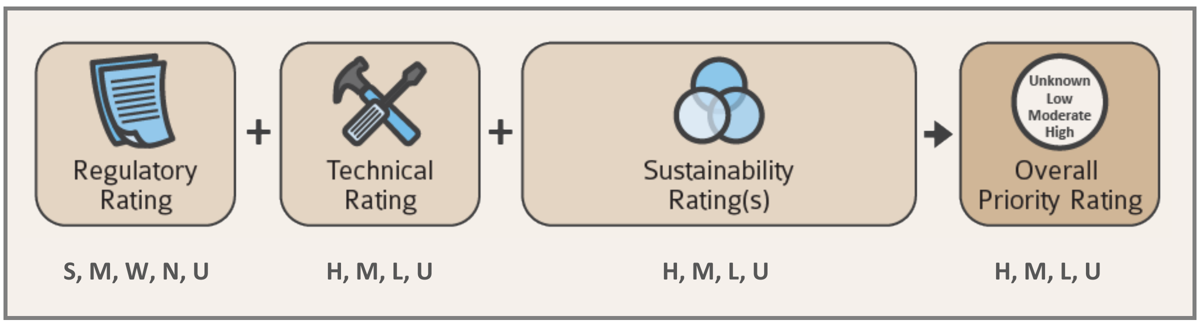


Figure 3.13: Establishing an Overall Priority Rating for a Problem Condition[4]

Question 2 What is the relative importance of each problem condition?

For individual ratings to be useful in supporting decision-making, they must be compared to determine their relative importance. This is expressed as a ranking for each priority problem condition. Two options are illustrated in **Figure 3.14**. Identified problems can either be put into a ranked order or grouped by their priority ratings. Establishing ranked orders consists of lining up the applicable problem conditions for each receiving water or segment from highest priority to lowest, with the higher priorities normally constituting the greater management priorities. In many instances, problem conditions will have "tie scores". Rather than conducting further analysis to differentiate between them, managers may want to consider grouped rankings.

[4] This example shows a single Sustainability Rating that reflects both economic and social considerations. Another option would be to generate distinct Economic and Social Ratings (i.e., Regulatory + Technical + Economic + Social Ratings → Overall Priority Rating). Neither of these options is right or wrong, and which of them is chosen would likely depend on the availability and quality of social and economic data. For simplicity, a combined Sustainability Rating is utilized throughout the remainder of this document.

	RANKED ORDER EXAMPLE	GROUPED RANKING EXAMPLE
↑ Increasing Priority ↑	1. Problem A (High Priority Rating) 2. Problem B (High Priority Rating) 3. Problem C (Moderate Priority Rating) 4. Problem D (Low Priority Rating) 5. Problem E (Low Priority Rating) 6. Problem F (Unknown Priority Rating)	**GROUP A** (High Priority Rating) • Problem A • Problem B **GROUP B** (Moderate Priority Rating) • Problem C **GROUP C** (Low Priority Rating) • Problem D • Problem E **GROUP D** (Unknown Priority Rating) • Problem F

Figure 3.14: Potential Options for Ranking Problem Conditions

On completion of problem prioritization, managers will have narrowed their initial inventory of problem conditions to a more focused Priority Problems List. They must next decide which of these conditions will be targeted for change in Step B. It's important to keep the qualitative nature of this exercise in mind. Its purpose is only to provide an informational basis for the comparison of different types of problem conditions. Rating and ranking systems, no matter how sophisticated, cannot replace the role of judgment in evaluating results.

Because of the uncertainty associated with most prioritization steps, knowledge and data gaps will also be an important output at this planning stage as well. For each problem condition reviewed, additional data and information may need to be collected as necessary to explore any or all of the specific evaluation criteria described. Managers may initially find that data and information relating to the economic and social aspects of a problem condition are difficult to identify or obtain. In the absence of applicable experience and data, analysis of these factors may be constrained. Data and information gaps should be carefully documented and later considered in the development of data collection strategies.

Figure 3.15 below provides a Review Checklist to guide managers through Task 3 completion. **Table 3.6** also shows how the three guiding questions are applied at each individual outcome level. These questions form the basis of the additional guidance on problem prioritization provided in **Sections 4.0** and **5.0**.

Key Concept 3.5 Sustainability and the triple bottom line

Sustainability is the practice of exploring the interconnections among economy, society, and environment to bring about the best solutions for people and the environment now and in the future. There are as many specific definitions of sustainability as there are groups trying to define it, and each may be useful in different situations and for its own purposes.

The phrase "the **triple bottom line**" (or TBL) was first coined in 1994 by John Elkington, the founder of a British consultancy called SustainAbility. He argued that companies should be preparing three separate bottom lines, often referred to as people, planet and profit. . The first is the bottom line of a company's "people account"—a measure in some shape or form of how socially responsible an organization has been throughout its operations. The second is the bottom line of the company's "planet" account—a measure of how environmentally responsible it has been. The third is the traditional measure of corporate profit—the "bottom line" of the profit and loss account. The concept of TBL is now used in a wide variety of disciplines, including environmental and resource management.

In the context of stormwater strategic planning, sustainability means that decision-making is guided by a balance of environmental, economic, and social considerations. There are three critical points in the planning process where this is imperative; first during the prioritization of problems (**Step A Task 3**), again during the targeting of end-state conditions (**Step B Task 1**), and finally in the selection of program strategies (**Section 6.0**). The reason for this is that all three processes require complex and sometimes controversial decisions to be made in support of potentially significant resource commitments. Rather than doing so purely on technical grounds, a sustainability approach can guide managers toward priorities and solutions with the best chances of economic feasibility and social acceptance. It should be noted that each of these processes substitutes "technical" for "environmental" factors. This is because the range of outcomes considered by stormwater programs is broader than just environmental (water quality) outcomes.

Review Checklist

Step A Task 3

Prioritizing Problem Conditions

At each Outcome Level, apply this task individually to all problem conditions identified in Task 2. Its purpose is to rate and rank the priorities of problem conditions.

Question 1: What is the priority rating of each problem condition?

✓ **Tier 1: Regulatory Screening** **REGULATORY RATING________**

- Identify regulatory requirements affecting priority.
- Identify regulatory constraints affecting priority.
- Assign a Tier 1 Rating. If an Overall Priority Rating can be assigned based solely on regulatory criteria, stop and document. If not, continue to Tier 2 Review.

✓ **Tier 2: Technical Review** **TECHNICAL RATING________**

- Evaluate the significance of the problem.
- Evaluate the certainty of the problem.
- Evaluate the controllability of the problem.
- Assign a Tier 2 Rating. If an Overall Priority Rating can be assigned based solely on technical criteria, stop and document. If not, continue to Tier 3 Review.

✓ **Tier 3: Sustainability Review** **SUSTAINABILITY RATING________**

- Identify economic factors affecting priority.
- Identify social factors affecting priority.
- Assign a Tier 3 Rating. If desired, consider separate ratings for economic and social factors.

✓ **OVERALL PRIORITY RATING________**

- Jointly consider the results of Tier 1, 2, and 3 reviews to assign an Overall Priority Rating for each problem condition.

Question 2: What is the relative importance of each problem condition?

✓ **Priority Rankings**

- Assign relative rankings to all identified problem conditions. Consider as appropriate ranked order and group ranking approaches. Consolidate individual results into one or more ranked lists for consideration in Step B.

✓ Document all data and information gaps identified during Task 3 completion.

Figure 3.15: Review Checklist for Prioritizing Problem Conditions

Step B Targeting Outcomes

The establishment of targeted outcomes is the first critical step toward the development of the control strategies needed to resolve identified problems. Up to now, planning has concentrated on identifying and prioritizing problems. From here forward, the focal point will be to identify desired changes and to develop specific strategies for achieving them. Targeted outcomes will define what a control strategy is designed to achieve, and in turn how specific actions can be directed to facilitate these changes.

Targeting starts with the list of Outcome Level 2 through 6 priority problem conditions identified above in **Step A**. For each identified priority problem, managers should consider establishing one or more targets. There is no simple formula for setting these targets. Depending on the outcome, this can be one of the most uncertain and speculative parts of the planning process. That said, managers should not shy away from setting specific targets, in fact they are necessary. In addition to helping to direct programs toward the resolution of problems, targeting establishes a context for establishing measurability, interpreting results, and evaluating success over time.

Figure 3.16 provides an overview of a general process for targeting outcomes. It consists of three general tasks. First, managers will establish the end-state conditions they believe are necessary to define success. Once this long-term vision is defined, they'll concentrate on defining the roadmap needed to get there. Interim milestones will help to direct efforts and provide feedback for making adjustments along the way. Finally, managers will review these end-state and interim targets with an eye toward their measurement and assessment. The upfront identification of applicable data requirements will ensure that outcomes are measurable and that managers are able to evaluate them once implementation phase data become available.

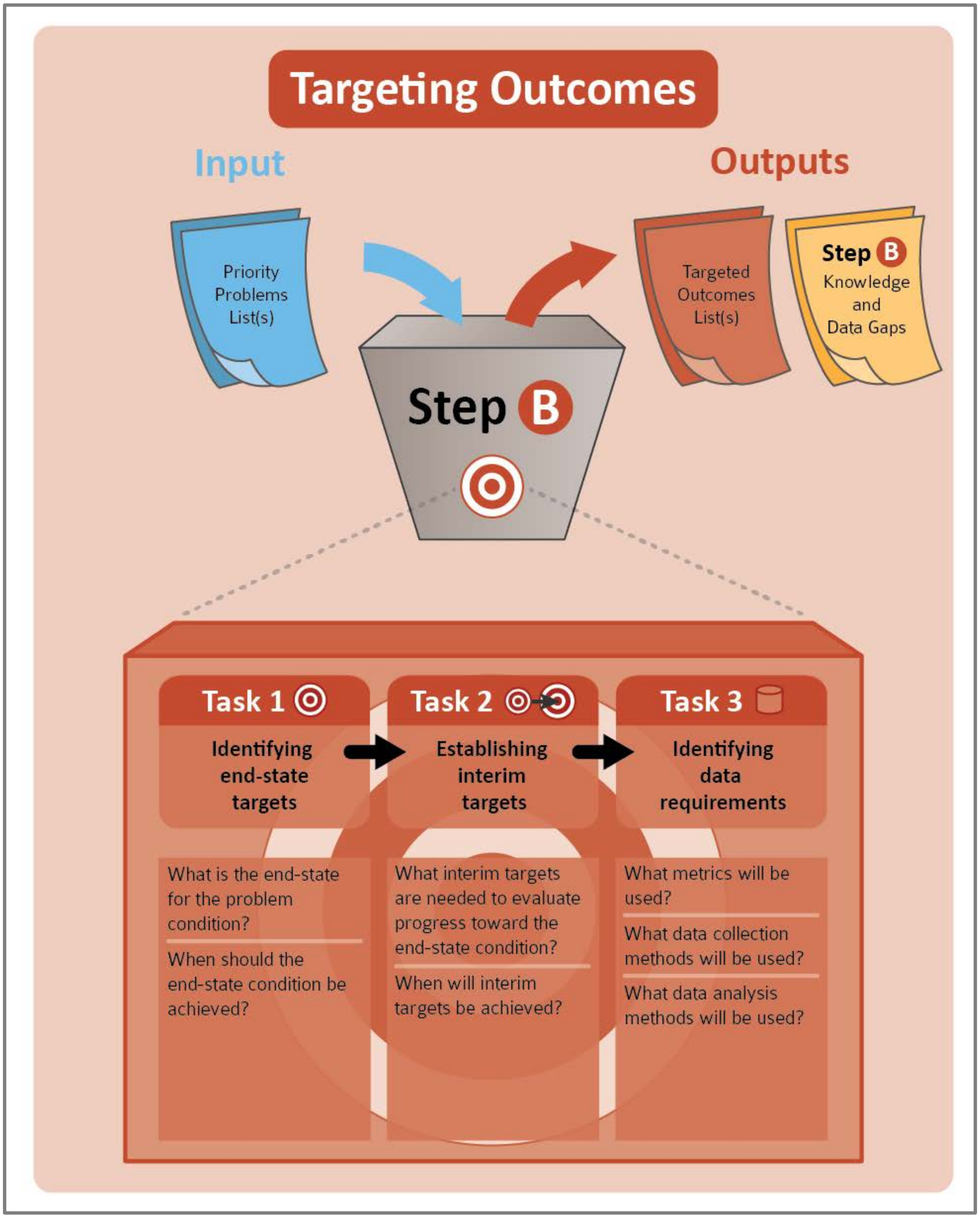


Figure 3.16: General Process for Targeting Outcomes

Task 1 Identifying end-state targets

In Step A, managers defined the nature and magnitude of individual problem conditions. Under Step B, managers will focus on defining the changes to be sought in those conditions. It addresses two general questions.

Step B Task 1 Key Questions
Identifying End-state Targets

Inputs	Key Questions	Outputs
Priority Problem Conditions	**Question 1:** What is the end-state for the problem condition? **Question 2:** When should the end-state condition be achieved?	**End-state Targets**

Question 1 What is the end-state for the problem condition?

End-state conditions describe a "no problem" state. Once achieved, they can be considered to represent long-term success for the particular outcome under consideration. For each priority problem condition identified, managers must define what they consider long-term success to be. That is, under what circumstances would the condition no longer represent a problem?

Approaches to evaluating end-state conditions are very different than those employed for existing conditions. End-state conditions are focused primarily on defining long-term success. From a planning perspective, they provide the "goal post" for each priority outcome. There is no simple or straightforward approach to defining them. The discussion below describes several general approaches that can provide structure in identifying these conditions. As described, targeting starts with the establishment of provisional targets followed by a review of initial results using many of the same general considerations discussed previously during problem prioritization. While many of the details change from one process to the next, this continuity underscores the importance of these factors as core planning considerations.

General Approaches to End-state Targeting

Four general approaches to setting targets are described below. Any management approach will likely rely on all of them to some degree, with each applying in different circumstances.

Targeting to Regulatory Requirements

Regulatory requirements should also always be considered when setting targets. Since permits and other regulatory directives often leave little room for interpretation, compliance with them must be maintained. For example, if a TMDL requires compliance with Water Quality Based Effluent Limits (WQBELs), the program must be designed to achieve them. This is true in any case where a target is explicitly or implicitly defined in a permit or TMDL.

Targeting to Higher Outcome Levels

This approach involves establishing targets in relation to desired changes in higher level outcomes. For example setting a target for behavioral change (Level 3) that is designed to achieve a source reduction (Level 4); or targeting a group of source reductions (Level 4) to collectively achieve a specific improvement in MS4 discharge quality (Level 5). As previously discussed, problem conditions are assumed to be sequentially linked in “chains” (or “webs”) of cause and effect relationships. It follows that changes in these conditions are also sequentially linked, and that managers will benefit from exploring the potential implications of “dialing” a particular outcome up. This "upward targeting" approach centers around the relationship of two variables. The lower level outcome can be considered an independent variable and the higher level outcome a dependent variable. Or to put it another way, a change in a "causal" outcome can be targeted to achieve an "effect" in the other outcome. Where relationships between the two outcomes are well-understood, or can be reasonably hypothesized, this should be the approach of choice. In practice, this is often not the case, so other approaches must be considered.

Targeting to Resources

Every MS4 program is subject to resource limitations. Normally programs cannot be resourced to achieve all priority outcomes, so decisions must be made about how much and how quickly they can be achieved. Individual targets must always be established within the context of overall resource availability. For example, how much training or outreach can be conducted with existing staffing? Or how many structural BMPs can be constructed and maintained? It's important to emphasize that targeting to resource availability may often not be sufficient for meeting explicit regulatory requirements, or to satisfy the expectations of regulators or third parties.

Targeting to Learn and Adapt

As emphasized throughout this document, managers often lack the knowledge base needed to understand the types and amounts of change that can be achieved. Or the potential implications of a specific action or change will be unknown. As such, the certainty needed to pursue any of the previous three targeting approaches may be lacking. In many cases, programs or initiatives must be implemented with a general objective of learning through experience. This "trial and error" approach relies heavily on establishing and exploring assumptions or hypotheses, accumulating experience through ongoing implementation, and making adjustments through an adaptive management process. This is not to say that other approaches lack a focus on learning; just that sometimes an active learning process must precede the establishment and refinement of targets. Given that linkages between many outcomes may never be confidently established, this allows managers an important means of better defining achievable targets over time.

One approach might be to implement a program according to a specific plan of action (Level 1) and to monitor for potential changes at one or more other outcome levels. For example, if a particular set of activities is directed to reducing loadings of a pollutant in a watershed area, managers might also seek to determine whether or not specific changes are occurring in downstream receiving waters over time. By setting "experimental" targets and tracking measurements for both types of outcomes, they can learn more about each outcome individually, and work toward the establishment of linkages between them over time. There is conceptually little limit to the range of targets that can be addressed experientially. The critical unifying factor is increasing **measurability**. Only by committing to the measurement of individual outcomes, and to using data to answer specific, directed questions, can managers actively support an adaptive management process. As measurability increases over time, basic assumptions about relationships between outcomes can be replaced with **working hypotheses** that can in turn be refined and further explored.

Sometimes managers will want to explore changes in **individual outcomes** regardless of their expected effects on other outcomes. This allows them to proceed with targeting outcomes even where linkages between them are not well understood. One variation on this approach is the establishment of **stretch targets**. Managers will often have a good idea of what they've been able to accomplish in the past, and therefore where they might seek additional improvements. For example, they might target a 10% increase in knowledge of the difference between sanitary sewers and storm drains in residents; or a 5% reduction in discharge violations at construction sites. These targets give managers a means of "stretching" to see what can be done cost-effectively or within available resource commitments. In doing so, they can continue to actively learn while pursuing increases in measurability that might later be used to explore linkages. It is likely that some of the most significant program achievements will be obtained using this approach because it can be iterated more simply and quickly, and does not depend on the establishment of relationships which may eventually turn out to be incorrect.

In theory, as individual targets are "lined up" across multiple outcome levels, they will provide the linkages necessary to connect program implementation to receiving water improvements. Given the number and complexity of relationships between individual outcomes (see Key Concepts 3.3 and 3.4), this can be difficult to achieve. Nonetheless, it remains an important design principle that should be followed wherever possible. This might start with simple qualitative linkages (e.g., a constituent match between a specific source type and a receiving water exceedance). Over time, as targeted implementation proceeds and measurability increases, these relationships can be strengthened and quantified. Given, however, that some linkages may never be established, managers should also pursue a general goal of demonstrating improvements across a variety of outcome types.

Potential Review Factors

Regardless of which general approaches are taken, the initial list of targets generated should be considered provisional, and reviewed and revised as needed. Reviews should include a consideration of any potential regulatory, technical, economic, or social factors that may affect the feasibility or desirability of attaining the target (**Figure 3.17**).

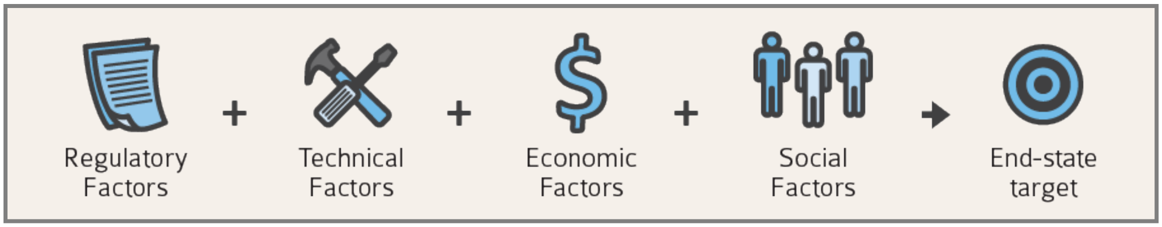


Figure 3.17: Factors Relevant to Setting Targets for Outcomes

Since these factors were already introduced above during problem prioritization (Step A Task 3), readers are referred to that general discussion for additional background. They are reminded, however, that the application of these factors during targeting is for a fundamentally different purpose. Whereas the former process was intended to establish the priority of a problem condition, the purpose here is primarily to define the magnitude of the change to be sought. Because of this, some differences exist in the application of these criteria, particularly with respect to potential cost implications. As noted above, a variety of costs may apply to the MS4 program itself, to target audiences, or to society at large. Given that the resources to be applied to potential solutions are always limited, measures of efficiency and benefit should also be considered. These include cost-benefit, cost-effectiveness, and return on investment (ROI).

Table 3.6 provides a list of potential review questions that might be considered.

Question 2 When should the end-state condition be achieved?

Every targeted change in conditions should specify a timeframe. Without this, it's impossible to assess whether or not a program is making reasonable progressing toward it. As noted above, some timeframes will be established by permit or TMDL requirements. Where there is discretion, managers should pay particular attention to the time needed to realistically achieve the type of change targeted. This should include both the time needed to fully implement control measures, and the additional time needed for resultant changes to occur. **Figure 3.18** provides a comparison of the timeframes generally needed to achieve different outcome types.

Table 3.6: Potential Review Questions for Evaluating Provisional End-state Targets

Regulatory Considerations

- Is the target legally required (explicitly or implicitly)?
- Do legal or regulatory restrictions apply to acheivement of the target?

Technical Considerations

- Is the target technically feasible and acheivable?
- Are potential control measures and technologies readily available?

Economic Considerations

- Is achieving the targeted change economically feasible and efficient?
- What are the costs of achieving the change? Are they one-time or ongoing? Who pays for them? Will it create or eliminate jobs?
- Can the targeted change be achieved cost-effectively?
- How do identified costs compare to the expected benefits of the change?
- What is the return on investment (ROI)?

Social Considerations

- Who is affected by the proposed change?
- Who might support or oppose the change? Why?
- Are there environmental justice issues associated with making or not making the proposed change?
- Is the change socially acceptable or supported?

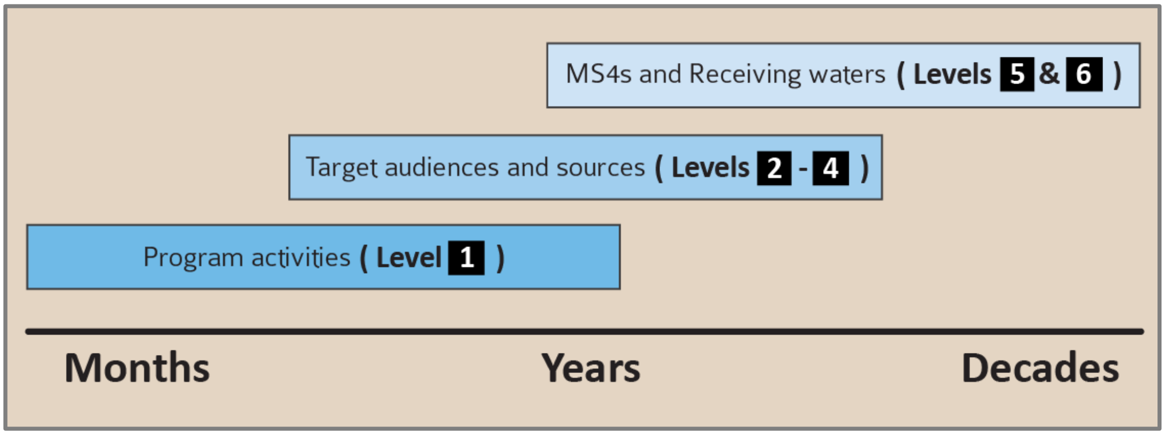


Figure 3.18: General Timelines Needed for Achieving Targeted Outcomes

Although not to be taken literally, this figure illustrates a general principle that timeframes for change are inversely related to the level of control exerted by a program. That is, they will be shortest for the outcomes that managers directly control (their own program activities) and increase from left to right with higher outcome levels. It's also important to consider the timeframes needed to measure the change. Even though a target may be achievable within a given number of years, the variability of sampling results can sometimes make it difficult to obtain reliable measurements of change within the same period.

Task 2 Establishing interim targets

Every targeted end-state condition will have a timeframe associated with it. Since many changes can take years, decades, or longer to achieve, a course of action will normally need to be set for incrementally achieving them. The concept of interim targets should already be familiar to many managers since they're routinely required in TMDLs, and many MS4s permits are increasingly setting specific timelines for achieving change.

The establishment of interim targets follows the general questions below.

Step B Task 2 Key Questions
Establishing Interim Targets

Inputs	Key Questions	Outputs
End-state Targets	**Question 1:** What interim targets are needed to evaluate progress toward the end-state condition? **Question 2:** When will interim targets be achieved?	**Interim Targets**

Question 1 What interim targets are needed to evaluate progress toward the end-state condition?

Interim targets are the milestones on the road to achieving end-state conditions. As stated, most targeted end-state conditions are likely to take years or decades to achieve, if at all. In the meantime, managers need to know if their efforts are properly directed and if satisfactory progress is being made. Interim targets can provide this structure and feedback.

Figure 3.19 illustrates the relationship of interim and end-state targets. In this example, four interim targets have been established. By designing implementation strategies to incorporate feedback through the assessment of interim targets, managers will provide themselves the opportunity to learn and adapt as they go.

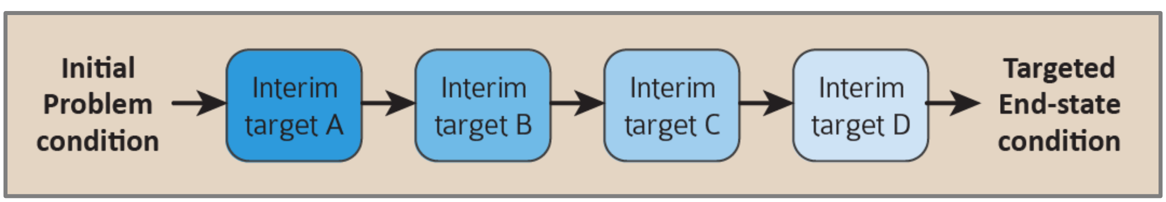


Figure 3.19: The Role of Interim Targets in Achieving End-state Conditions

Interim targets should reflect the time it takes to "ramp up," refine, and fully implement the programs expected to drive targeted changes. Once initial changes have occurred, other higher level changes (behavioral changes, load reductions, etc.) will also take time to occur in response. There may also be a point at which maximum gains can be expected and the achievement of steady state conditions after that. Interim targets should establish milestones along the way necessary to realistically anticipate critical events in the implementation curve, and to make adjustments in response to results.

Question 2   When will interim targets be achieved?

At first glance, **Figure 3.19** may seem to imply a linear progression toward end-state conditions, but this is rarely the case. In some cases, changes may start slowly before control strategies are firmly established. In others, they may be more pronounced early on, with diminishing returns observed later. Although it's difficult to accurately forecast schedules for targeted change, the use of interim targets should realistically reflect real world conditions. Likewise, they should be adjusted along the way in response to experience and feedback.

On completion of this process, managers will have identified the targeted conditions they hope to achieve as a result of program implementation. These targets will later be considered for inclusion in the Source and Impact Strategy described in **Section 4.0** and the Target Audience Strategy described in **Section 5.0**. Given the numerous assumptions that must be made in the development of targets, knowledge and data gaps will also be prominent during this planning stage.

Task 3 Identifying data requirements

Now that targets for change have been identified, managers will need to identify how each outcome will be measured, what data are needed to allow measurement, and how these data will be collected and analyzed.

It is critical that each of the questions below be addressed for every targeted outcome addressed in Step B. Where the establishment of data requirements cannot be satisfactorily addressed up front (e.g., there's no available option for collecting the desired data), they may need to be documented as knowledge or data gaps (**Step C**).

Question 1   What metrics will be used?

This question addresses how managers will know when a targeted outcome has been achieved. Metrics are the unambiguous expression of an outcome. Up to now, outcomes have been discussed at a fairly general level ("a decrease in copper concentrations," "an increase in the percentage of workers understanding a specific concept," etc.). Before moving to implementation and assessment, it's necessary to convert these targets into very specific, measurable terms. In general, this means a more specific formulation of the outcome statement and the assignment of units of measure or assessment. This concept will be explored further in **Section 7.0**.

Question 2 What data collection methods will be used?

This question addresses how data will be collected to allow a condition or result to be tracked or assessed. **Table 3.3** provides a general listing of potential resources for collecting data and information by outcome level, and **Section 6.0** introduces a variety of data collection activity types typically used by stormwater programs. Data collection options are also explored further for each outcome level in **Sections 4.0**, **5.0**, and **6.0**. **Section 7.0** will also further explore data collection objectives and options. While managers may often have a very good idea of how data will be collected, it's prudent to stop and make sure that this is true for each identified outcome.

Question 3 What data analysis methods will be used?

The last consideration for any targeted outcome is how the data that are collected will be evaluated. As above, specificity is absolutely critical. Managers may often have a better idea of how they'll collect data than what they'll do with it. Failing to identify specific analytical approaches up front is a common mistake that can severely limit the explanatory value of data. Moreover, the choice of analytical method can dictate what specific metrics should be used, how the data should be collected, and the quality of the result. **Section 7.0** further explores data analysis objectives and options.

Figure 3.20 below provides a Review Checklist to guide managers through Step B completion.

Review Checklist

Step B Tasks 1, 2, and 3
Targeting Outcomes

At each Outcome Level, apply this task individually to all conditions selected for targeting in Step A Task C (Prioritizing Problem Conditions). Its purpose is to identify specific targets for change in problem conditions.

✓ **End-state Targets (Task 1)**
Consider the following questions:

Question 1: What is the end-state for the problem condition?
Select an approach type for establishing provisional targets. Apply and review each provisional target and revise as necessary.

Question 2: When should the end-state condition be achieved?
Consider the time needed to fully implement control measures and for resultant changes to occur, and the timeframes needed for measurement.

✓ **Interim Targets (Task 2)**
Consider the following questions:

Question 1: What interim targets are needed to evaluate progress toward the end-state condition? Consider milestones in the implementation curve, and the need to evaluate incremental progress.

Question 2: When will interim targets be achieved? Consider the time needed to fully or partially implement control measures and for resultant changes to occur, and the timeframes needed for interim measurement.

✓ **Data Requirements (Task 3)**
For each end-state or interim target, consider the following questions:

Question 1: What metrics will be used?
Question 2: What data collection methods will be used?
Question 3: What data analysis methods will be used?

✓ **For each priority outcome, document interim and end-state targets, and the data requirements necessary to track and evaluate them.**

✓ **Compile one or more lists of targeted changes for each outcome level and supporting documentation for listed conditions.**

✓ **If a priority outcome is not or cannot be targeted, document the reason.**

✓ **Document all Step B data and information gaps.**

Figure 3.20: Review Checklist for Targeting Outcomes

Step C Documenting Knowledge and Data Gaps

Uncertainty is an unavoidable feature of stormwater management. As described throughout this section, every major planning step involves some degree of speculation. Knowledge and data deficits will therefore continually be revealed as planning progresses.

As an example, elevated bacteria levels in receiving waters and MS4s are determined to be a problem condition. In response, restaurants are implicated as contributing sources and program activities directed to mitigating specific pollutant-generating activities (food grease disposal and outdoor rinsing of floor mats) at those facilities. In the absence of supporting data and information, two critical assumptions have been made; first that these facilities are significant sources of bacteria, and second that these specific practices are the causes of these discharges. Stormwater management is largely a hypothesis testing endeavor, and assumptions are a necessary part of that approach. As indicated, it would simply be impossible to move stormwater programs forward without them.

Uncertainty can never be an excuse for inaction, but managers should also be cognizant of the need to treat critical assumptions as provisional hypotheses, and to gather the data and information necessary to refine and replace them as necessary. To allow their eventual resolution, knowledge and data gaps should be documented throughout the planning process, and strategies developed for addressing critical gaps through targeted data gathering initiatives (monitoring, special studies, implementation tracking, etc.; see **Section 7.0**).

Figure 3.21 illustrates a general process for documenting knowledge and data gaps. As previously indicated, this idealized process shows the identification of gaps as discrete planning steps. In reality, this review should be ongoing throughout the entire planning process.

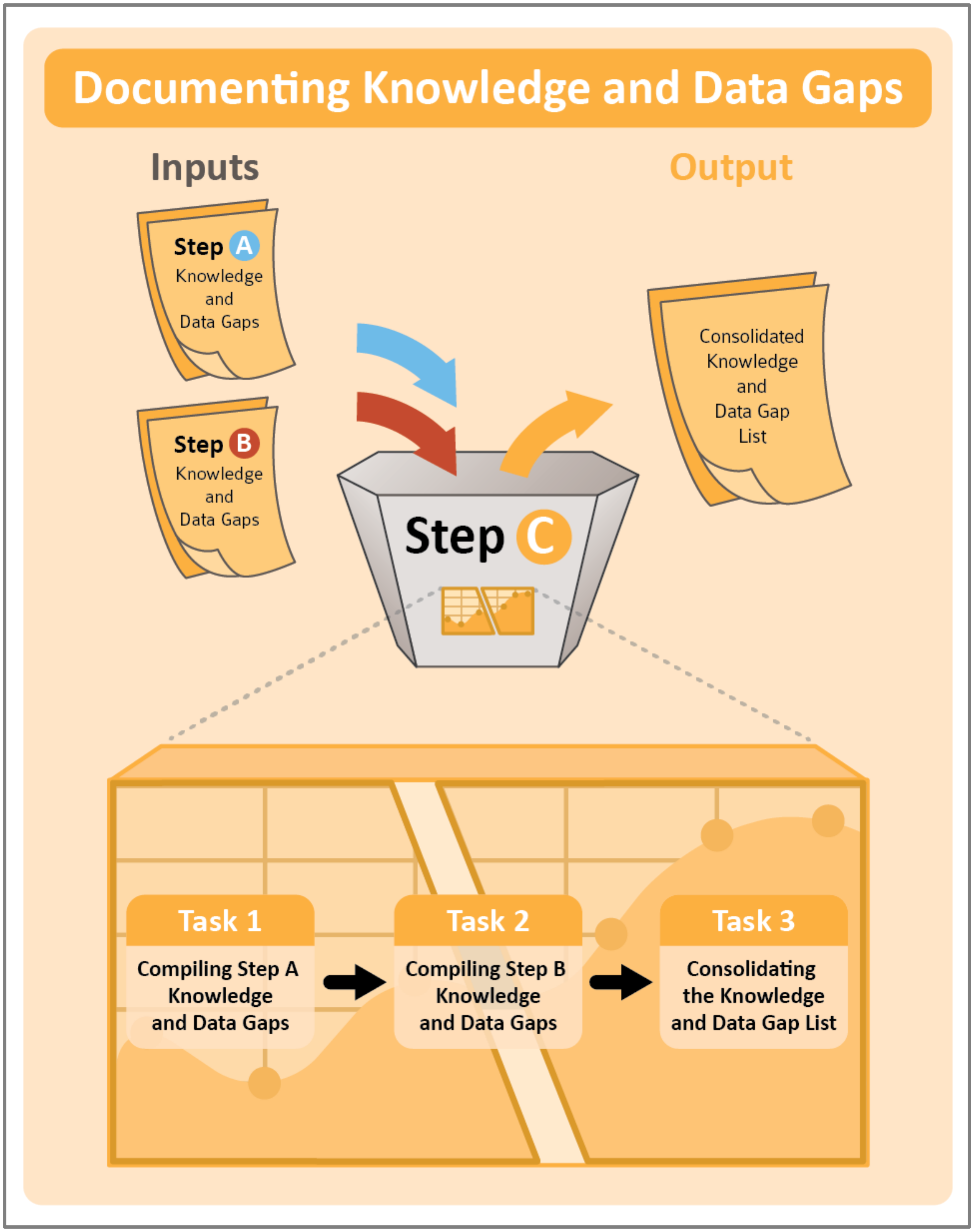


Figure 3.21: General Process for Consolidating Knowledge and Data Gaps (Step C)

3.4 Stormwater Strategic Plan Completion (Stage 3)

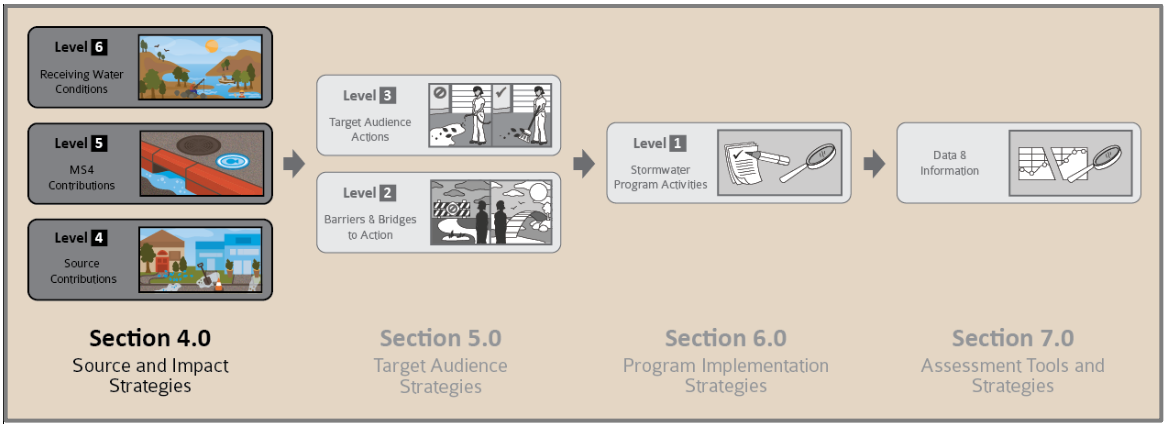
The final stage of the strategic planning process is Plan Completion. This is where all of the individual elements described throughout this document are pulled together, reviewed, revised, and finalized. All Stormwater Strategic Plans will be different depending on their unique needs and circumstances, but each of the elements listed in **Table 3.7** should be considered for potential inclusion.

Table 3.7: Potential Stormwater Strategic Plan Content

Element	Explanation
Source and Impact Strategies	Addresses Outcome Levels 6, 5, and 4, the physical component of stormwater management. Managers consider a variety of parameters to evaluate sources, MS4s, and receiving waters. See **Section 4.0**.
Target Audience Strategies	Addresses Outcome Levels 3 and 2. They focus on understanding who is responsible for identified source contributions, and which specific behaviors are contributing to them. Managers need to know what each identified target audience should be doing differently, and to have a clear understanding of the influencing factors standing in the way of these changes. See **Section 5.0**.
Program Implementation Strategies	Addresses Outcome Level 1. Their focus is on the selection and targeting of specific program activities necessary to facilitate changes in target audiences, and to provide the feedback necessary to track and evaluate the range of outcomes addressed by the Strategic Plan. See **Section 6.0**.
Assessment Tools and Strategies	Addresses all Outcome Levels. They identify the strategies and approaches needed to support ongoing characterization of conditions, to evaluate change or success, and to identify and address data and information gaps. See **Section 7.0**.

A comprehensive planning and assessment strategy will typically address a wide variety of individual outcomes, but their selection will ultimately reflect the specific details, priorities, and assessment objectives of each Stormwater Management Program. It's critical that readers understand that Stormwater Strategic Plans are not likely to actually be organized according to these four elements. The overall organization of any strategic plan is much more likely to follow broad source categories. However, each of these elements will have differing degrees of applicability within the specific components of this broader organizational scheme.

Section 4.0: Source and Impact Strategies



*This section describes the development of **Source and Impact Strategies**, the first of four strategic planning components initially introduced in Section 3.0. Source and impact planning addresses Outcome Levels 6, 5, and 4. This is the physical component of stormwater management. During planning and assessment, managers will consider a variety of parameters to characterize water quality and hydrologic conditions at sources, within MS4s, and in receiving water bodies. Once problem conditions are identified and prioritized, objectives for change can be established and strategies developed for achieving them.*

Completed Source and Impact Strategies will inform the subsequent development of Target Audience trategies in Section 5.0, and will inform the subsequent selection of Assessment Tools and Strategies in Section 7.0.

4.1 Background

This section utilizes the strategic planning process presented in **Section 3.0** to identify and prioritize sources of pollutants and flows to receiving waters. It begins with the evaluation of receiving water problems, and then “works back” toward potential contributing sources via MS4s and associated drainage areas (**Figure 4.1**). Following this approach, source priorities can be identified in response to demonstrated priority water quality impacts. However, since receiving water and MS4 impacts are often not well-documented, "preventive" approaches that focus primarily on the potential of sources to generate flows or pollutants must also be considered. Both scenarios can make sense depending on individual circumstances and data availability, and neither is necessarily advocated over the other.

This section addresses **physical systems**, including the generation of urban runoff pollutants and flows within drainage areas, their transport via MS4 systems, and their impacts on waterbodies.

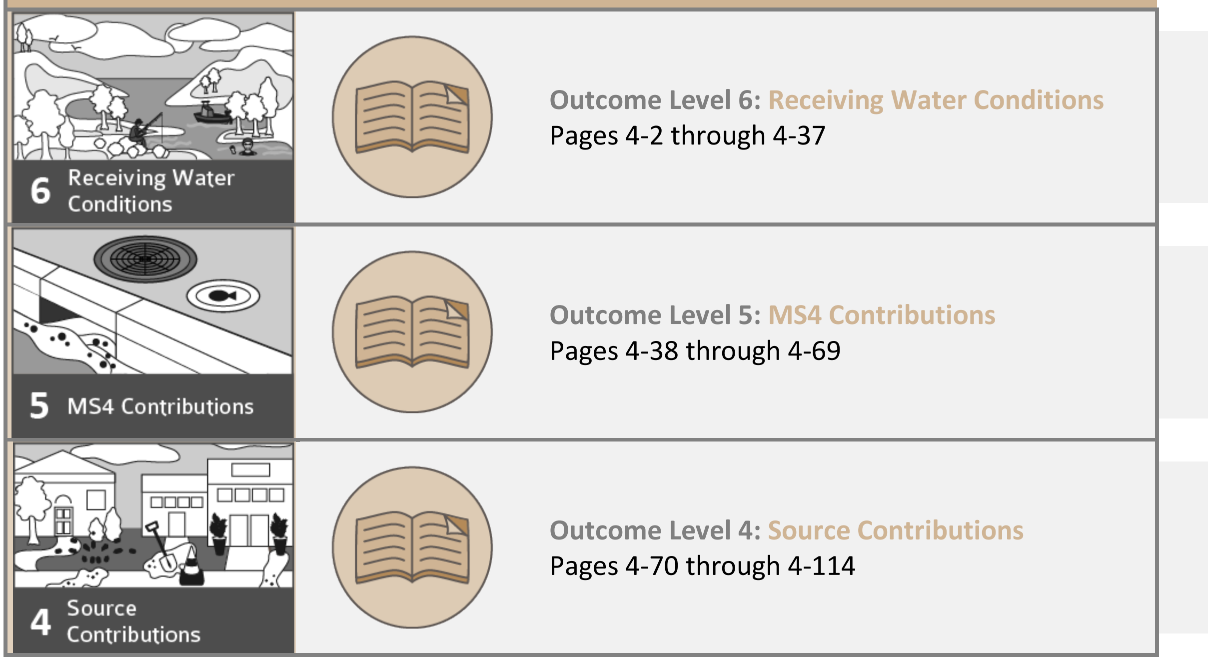
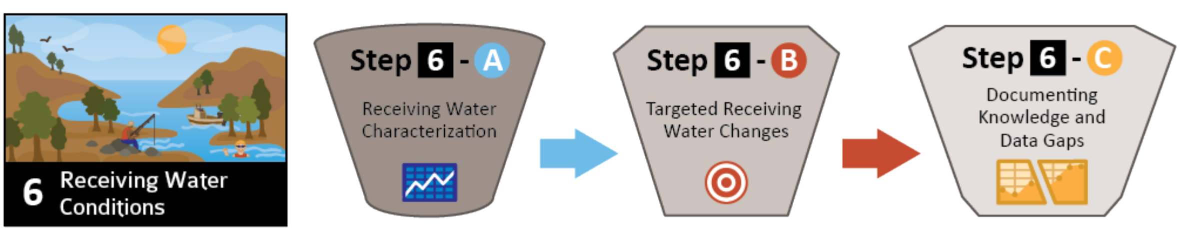


Figure 4.1 Primary Components of Source and Impact Strategies

4.2 Outcome Level 6: Receiving Water Conditions

Level 6 planning is a three-step process.



In **Step 6-A**, existing data and information are reviewed to evaluate conditions in receiving waters. Initial results are then narrowed to focus on priority problem conditions. **Step 6-B** focuses on defining the changes that will be sought in these conditions over time. Finally, **Step 6-C** identifies the knowledge and data gaps discovered along the way, so that future data collection initiatives can be directed toward resolving them.

Step 6 - A Receiving Water Characterization

As shown in **Figure 4.2**, Step 6-A consists of three tasks. Characterization begins with a review of available data and information for applicable receiving waters. **Table 4.1** identifies a variety of data and information resources that can be used to inform Level 6 strategic planning. These can include data collected by the MS4 program itself, most typically previously-conducted receiving water monitoring. Likewise, a variety of external sources such as regulatory agencies, research institutions, and published research, may be useful in augmenting data collected through local programs.

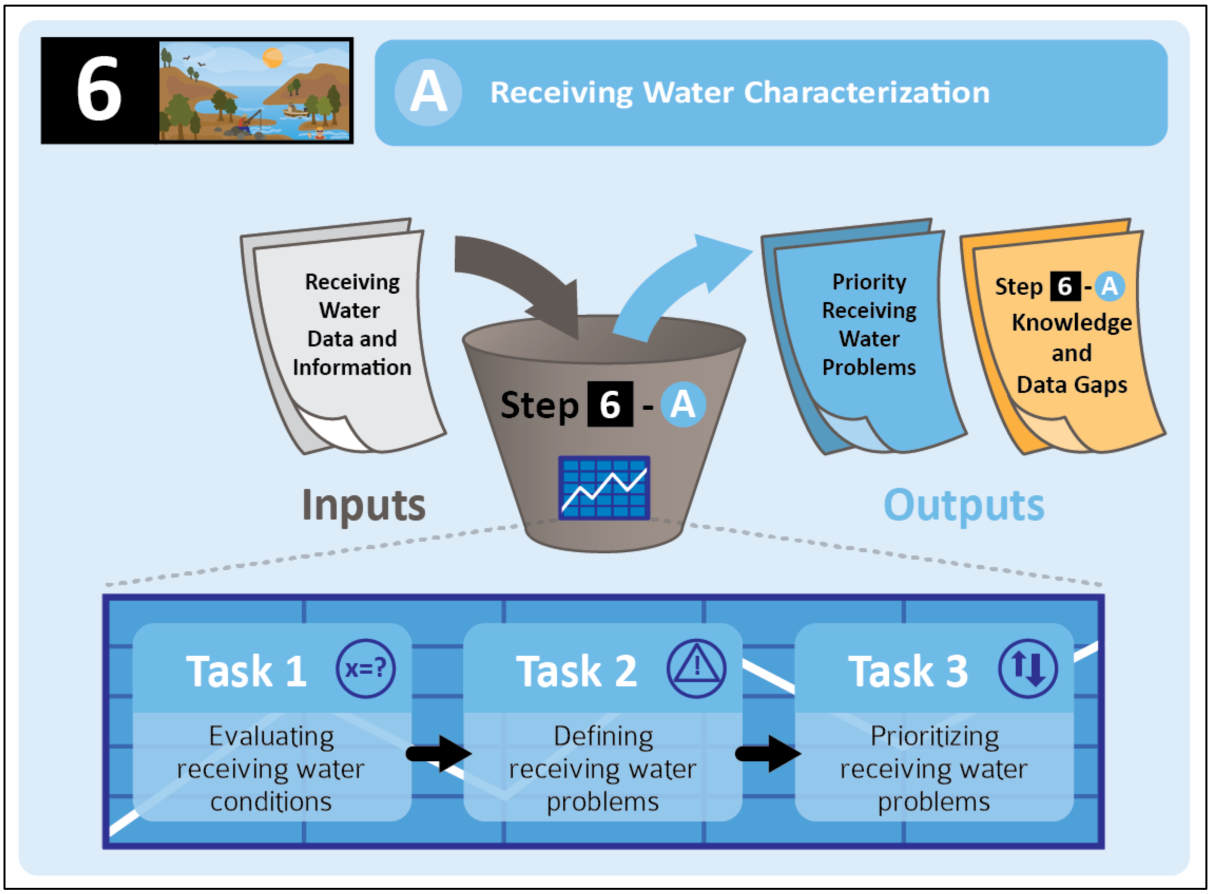


Figure 4.2: Receiving Water Characterization (Step 6-A)

Table 4.1: Potential Sources of Receiving Water Data and Information

- ☑ Receiving water and MS4 monitoring program sampling data and reports
- ☑ SWRCB Water Quality Control Plans (beneficial use designations, etc.)
- ☑ CWA Section 303(d) lists
- ☑ Total maximum daily loads (TMDLs)
- ☑ Regulatory agencies and research institutions (SCCWRP, WERF, etc.)
- ☑ Online repositories, directories, and databases (CERES, SWAMP, etc.)
- ☑ Published or unpublished research, literature, and technical reports
- ☑ Special investigations
- ☑ Other (as needed)

Task 1 Evaluating Receiving Water Conditions

Managers will first identify and evaluate available data and information for each water body receiving discharges from MS4s under their responsibility and control. At this point all receiving water conditions should be of interest. Evaluations are guided by two key questions.

Step 6-A Task 1 Key Questions
Evaluating Receiving Water Conditions

Inputs	Key Questions	Outputs
Available Data, Information, and Results	**Question 1:** What are current receiving water conditions? **Question 2:** How are receiving water conditions changing over time?	**Existing Receiving Water Conditions**

Question 1 What are current receiving water conditions?

Planning will initially focus on the current state of receiving waters. In this context, “receiving water” can mean entire water bodies, segments, or in some situations multiple water bodies. The receiving waters of most interest to managers should be those receiving discharges from drainage areas under their authority or responsibility.

Nature and Magnitude

The **nature** of a receiving water condition refers to its general characteristics or attributes. Although there are many ways to classify receiving water conditions, they're usually grouped according to chemical, biological, toxicological, or physical parameters. **Table 4.2** lists many conditions that are typically considered for receiving waters. It's important to emphase that many of these attributes will apply to each receiving water. That is, to fully characterize a water body, a variety of conditions will apply.

Table 4.2: General Types and Examples of Receiving Water Conditions

Type of Condition	Examples
Chemical Conditions	
Constituents in flows (wet, dry, and ambient)	• Chemical constituent concentrations or loads (metals, pesticides, nutrients, etc.)
Constituents in sediments	• Metals, pesticides, nutrients, etc.
Toxicological Conditions (aquatic and sediment; acute and chronic)	
Toxicity from chemical constituents	• Metals, pesticides, nutrients, etc.
Toxicity from other stressors	• Temperature, turbidity, etc.
Biological Conditions	
Pathogens and indicators	• Bacterial indictors in wet and dry weather flows • Pathogens (bacteria,. viruses, protozoa, etc.) in wet and dry weather flows
Habitat and communities	• Macro-invertebrate community integrity • Biodiversity • Algal abundance and diversity • Habitat integrity (wetlands, riparian cover, etc.)
Physical Conditions	
Physical condition of channels and banks	• Geomorphic conditions • Erosion and sedimentation • Hydromodification • Extent and amount of trash
Flow conditions within channels	• Presence or absence of flow or ponded water • Volume, velocities, and durations of flows
Other	• pH, temperature, conductivity, dissolved oxygen, turbidity

In addition to nature, it's necessary to understand the magnitude of each receiving water condition. **Magnitude** describes its dimension or scale. Depending on the type of condition, this might include a number of different things, e.g., the average concentration of a chemical constituent, the volume or weight of trash and debris, or the peak velocity of stormwater flows. Together, nature and magnitude provide a basic description of each receiving water condition. It's also important to consider how each condition varies in time and space.

Variability

Prevalence and distribution describe the variability of a receiving water condition. **Variability** refers to how spread apart the measurements in a distribution are, or how they vary from each other temporally or spatially. **Temporal variability** describes how often or frequently the condition occurs, or how it varies over time. For example, bacterial indicators that exceed regulatory benchmarks in one-third of sampling events over the dry season. **Spatial variability** describes the physical patterns of dispersal of the condition within the receiving water. For instance total zinc concentrations that are above water quality standards at 2 of 10 monitoring stations. These results might not be representative of the entire water body; whereas, exceedances at a higher number of stations might indicate a condition that is highly distributed.

Some receiving water conditions vary according to regular **patterns**. For example, dissolved oxygen concentrations are generally in a constant state of flux on a daily basis and seasonally. Many receiving water conditions vary significantly by season. For instance, changes in flow velocities, volumes, and durations, seasonal spikes in temperature, seasonal changes in macro-invertebrate abundance and community structure, and seasonal changes in nutrient levels and algal production. Wet and dry weather conditions, normally represent two entirely distinct situations. It's therefore often necessary to evaluate receiving water conditions independently for wet and dry weather.

Collectively, nature, magnitude, and temporal and spatial variability help to define the **significance** of a receiving water condition. Along with other factors considered below, significance plays an important role in determining whether or not a condition is considered a problem, and if it is a priority for future action.

Certainty and Controllability

Certainty refers to the confidence that managers have in their assessment of a receiving water condition. It makes little sense to expend significant program resources in addressing receiving water conditions that are not well understood. Conclusions drawn on small sample sizes can be misleading if they fail to adequately represent the nature, magnitude, prevalence, or distribution of a condition. Ideally, evaluation of receiving water conditions will include statistical analysis of data to determine trends, range, mean and variance within desired confidence levels. Due to the high variability of most water quality data, acceptable confidence levels usually require robust data sets or large changes. Unexplained variability indicates uncertainty. To achieve statistically sound support for management decisions, receiving water data must usually be collected over sufficient periods to establish baselines and confirm trends.

Resolving identified data and information gaps will increase the certainty associated with receiving water conditions, so it's important to continue characterizing conditions that are initially not well understood. Complex interactions between attributes of the receiving water (e.g., hardness and metals; pH and metals) often require additional data to establish reasonable certainty. Where possible, managers should rely on multiple data sets or lines of evidence including water quality, toxicity, biological and physical data.

Controllability describes the potential to influence changes in a receiving water condition. A condition that does not have a reasonable chance of being successfully controlled (e.g., levels of bacterial indicators immediately after storms) may also not be a good candidate for resource commitments. To understand the controllability of a receiving water condition, managers generally need to know something about contributing sources, migration pathways, and program implementation options. Since much of this information is not addressed until later planning stages, controllability can sometimes initially be difficult to characterize. It can be revisited as additional data and information become available.

Question 2 How are receiving water conditions changing over time?

Trends are increases, decreases, or other discernible changes in the magnitude, prevalence, or distribution of a condition over time. Receiving water conditions can sometimes change significantly over time. Managers should be interested in knowing whether a receiving water condition is trending upward or downward over time. For example, increases in hydromodification or pollutant loadings due to urbanization, or temperature increases due to climate change or the addition of impervious surfaces. Trend analysis is critical for describing change. Some changes in receiving water conditions can also be expected to result from program implementation over time. To support the evaluation of changes, it's important that a baseline of existing conditions be established, and that changes in key parameters are tracked over time.

The output of Task 1 will be the documentation of a variety of receiving water conditions. Each individual receiving water or segment evaluated may have its own list. Results may include a range of conditions and should be as inclusive as allowed by existing data and information. Where data are insufficient to fully describe a condition, knowledge and data gaps should be documented for consideration in future data collection strategies. Identification of problem conditions will occur in Task 2. **Figure 4.3** provides a Review Checklist to guide the completion of Task 1.

Review Checklist

Step 6-A Task 1

Evaluating Receiving Water Conditions

Apply this task very broadly across Outcome Level 6 sources of data and information. The purpose is to provide a "snapshot" of what is currently known about receiving water conditions.

- **Compile existing data, information, and results applicable to Outcome Level 6. Consider the following questions:**

  Question 1: What are current receiving water conditions?

  Consider: Nature, magnitude, prevalence, distribution, certainty, controllability, and spatial variability and trends

  Question 2: How are receiving water conditions changing over time?

  Consider: Variability and trends

- **Consolidate results into one or more summary lists of existing conditions. Categorize results as determined appropriate (by condition type, etc.).**
- **Compile supporting documentation for listed conditions.**
- **Select the conditions in the summary list(s) that will be further evaluated as potential problems in Task 2. Consider "back-up" lists for future evaluation as necessary.**
- **Document the critical data and information gaps identified during Task 1 completion.**

NOTES

Figure 4.3: Review Checklist for Evaluating Receiving Water Conditions

Task 2 Defining Receiving Water Problems

The objective of this task is to determine which of the receiving water conditions identified above constitute problems. Two key questions guide this evaluation.

Step 6-A Task 2 Key Questions
Defining Receiving Water Problems

Inputs	Key Questions	Outputs
Existing Receiving Water Conditions	**Question 1:** Does the receiving water condition represent a known or suspected beneficial use impact? **Question 2:** Is there independent evidence for designating the receiving water condition as a problem?	**Receiving Water Problems**

Question 1 Does the receiving water condition represent a known or suspected beneficial use impact?

The ideal reference point for defining receiving water problems is the establishment of linkages between measured conditions and their support for beneficial uses. **Beneficial uses** are the designated uses of a waterbody. Water Quality Control Plans (or Basin Plans) designate beneficial uses and establish water quality objectives for waters of the State. For waters within a specified area, a basin plan designates or establishes: (1) beneficial uses to be protected; (2) water quality objectives; and (3) a program of implementation to achieve the water quality objectives (Water Code §13050). **Table 4.3** provides a list of SWRCB beneficial uses. Objectives that support these uses can be numeric or narrative. To assess compliance with water quality objectives, available data are compared to the objectives themselves, or other applicable benchmarks, guidelines, or reference criteria. Exceedances of numeric objectives can be comparatively straightforward to interpret so long as applicable sampling and analytical protocols are adhered to. However, narrative objectives (e.g., ""waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses") may require a higher level of effort to relate to specific receiving water conditions. **Table 4.4** provides a number of hypothetical examples of receiving water conditions linked to specific beneficial use impacts.

Table 4.3: SWRCB Beneficial Use Designations

Municipal and Domestic Supply (MUN) Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

Agricultural Supply (AGR) Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

Industrial Process Supply (PROC) Uses of water for industrial activities that depend primarily on water quality.

Industrial Service Supply (IND) Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.

Ground Water Recharge (GWR) Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.

Freshwater Replenishment (FRSH) Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity).

Navigation (NAV) Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

Hydropower Generation (POW) Uses of water for hydropower generation.

Water Contact Recreation (REC-1) Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

Non-contact Water Recreation (REC-2) Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Commercial and Sport Fishing (COMM) Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

Aquaculture (AQUA) Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.

Warm Freshwater Habitat (WARM) Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Cold Freshwater Habitat (COLD) Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Inland Saline Water Habitat (SAL) Uses of water that support inland saline water ecosystems including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates.

Estuarine Habitat (EST) Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).

Wetland Habitat (WET) Uses of water that support wetland ecosystems, including, but not limited to, preservation or enhancement of wetland habitats, vegetation, fish, shellfish, or wildlife, and other unique wetland functions which enhance water quality, such as providing flood and erosion control, stream bank stabilization, and filtration and purification of naturally occurring contaminants.

Marine Habitat (MAR) Uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

Wildlife Habitat (WILD) Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Preservation of Biological Habitats (BIOL) Uses of water that support designated areas or habitats, such as Areas of Special Biological Significance (ASBS), established refuges, parks, sanctuaries, ecological reserves, or other areas where the preservation or enhancement of natural resources requires special protection.

Rare, Threatened, or Endangered Species (RARE) Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.

Migration of Aquatic Organisms (MIGR) Uses of water that support habitats necessary for migration, acclimatization between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish.

Spawning, Reproduction, and/or Early Development (SPWN) Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Shellfish Harvesting (SHELL) Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.

Table 4.4: Examples of Receiving Water Conditions Impacting the Beneficial Uses of a Stream and Estuary System

Type of Condition	Description of Condition and Supporting Data	Examples of Impacted Beneficial Uses	Applicable Criteria
Chemical Conditions			
Constituent concentrations in wet weather flows	Data compiled over a five-year period were compared to water quality objectives. Nutrient concentrations consistently exceed the objectives. The creek is 303(d) listed for nitrates.	WARM, EST	Water quality objectives, 303(d) listing
Biological Conditions			
Pathogens and indicators	Three years of data were reviewed to evaluate support for beneficial uses associated with human health. Determination of problem conditions is based on a comparison of existing conditions to water quality objectives based primarily on human health risk criteria.	REC-1, REC-2, MUN	Water quality objectives, AB 411 standards, TMDL limits
Toxicological Conditions			
Toxicity from chemical constituents	Analysis indicates toxicity in a limited number of samples at a few of the sites sampled. Toxicity Identification Evaluation indicates toxicity from organics, which is also corroborated by elevated pyrethroid measurements.	BIOL, RARE	Water quality objectives, California Toxics Rule, TMDL limits
Physical Conditions			
Habitat	Flow data indicate that increased imperviousness correlates to increases in the frequency of channel-forming flows. Comparisons to historic observations for these segments and comparisons to reference streams indicate that increased flows have reduced large woody debris, reduced vegetation, and widened the stream channel. Downstream sedimentation in the estuary is also observed. IBI scores appear low compared to reference streams, but data are not conclusive.	WILD, BIOL, REC2	Hydromodification requirements in MS4 permits and the Statewide Construction General Permit

Beneficial use impacts will often already have been identified through previous work. In particular, 303(d) listings and adopted TMDLs are by definition presumed to indicate one or more beneficial use impacts. Some NPDES permit requirements also establish specific objectives to protect designated beneficial uses. These are normally based on constituent concentrations or pollutant loadings, but they can also include biological, physical and toxicological criteria linked to a beneficial use. Non-compliance with any of these provisions may potentially be interpreted as evidence of beneficial use impacts.

Where evidence of a beneficial use impact exists, it may not always be definitive. Any determination of beneficial use attainment is only as valid as the data that it's built on. The science upon which any applicable criterion is based is also constantly evolving, and managers should remain cognizant of the need to consider the most currently available data and analysis. In some cases site-specific objectives that better represent actual conditions may be needed. As data sets are augmented over time, determinations of beneficial use impacts should be revised as needed.

Question 2 Is there independent evidence for designating the receiving water condition as a problem?

It's often not possible to directly link receiving water conditions to specific beneficial use impacts. In concept, the conditions that cause these impacts will eventually result in 303(d) listings, but it can often take years or decades for a listing to occur. In the meantime, many conditions can exist in a state that is not yet sufficient to trigger a listing, or for which future listings may be preventable. Many of these conditions can reasonably be considered to represent actionable problems.

To illustrate, monitoring of a stream's benthic macro-invertebrate community and habitat structure consistently produces low Index of Biotic Integrity (IBI) scores. IBI scores can be excellent integrators of the effects of changing water quality conditions over time, but might not in themselves demonstrate a clear lack of support for specific beneficial uses. It might be reasonably concluded that the scores represent a problem condition despite the lack of a defined beneficial use impact.

In a second example, nitrate concentrations in a stream are elevated, but below water quality objectives. DO levels are slightly depressed and historical patterns of development have removed much of the riparian canopy. There is substantial independent evidence that DO is impacted by eutrophication in aquatic systems and nutrient levels contribute to levels of eutrophication. There have been significant studies on the eutrophication of lakes, but the study of the relationship between nutrient levels, DO, algae mass and cover, bacteria concentrations, retention times and other factors in creeks, streams and estuaries is less comprehensive and often site-specific. Despite the absence of conclusive evidence of a beneficial use impact at this site, a weight of evidence suggests the existence of a potential problem condition.

The output of Task 2 will be a list of problems associated with each receiving water or segment evaluated. Results may include a range of confirmed or potential problems. Where data are insufficient to reasonably confirm a condition as a problem, it may be tentatively listed, and identified knowledge and data gaps considered for future data collection strategies. Prioritization of problem conditions will occur in Task 3.

Figure 4.4 provides a Review Checklist to guide the completion of Task 2.

Review Checklist

Step 6-A Task 2
Defining Receiving Water Problems

Apply this task individually to each Task 1 receiving water condition selected for further evaluation. The purpose of this task is to determine which of these conditions should be designated as problems.

✓ **For each identified condition, consider the following questions:**

Question 1: Does the receiving water condition represent a known or suspected beneficial use impact? If no, or if unknown, continue to Question 2.

Consider: 303(d) listings; TMDLs; exceedances of water quality objectives or other applicable criteria

Question 2: Is there independent evidence for designating the receiving water condition as a problem?

Consider: Variability and trends

✓ **Document known or suspected receiving water problem conditions.**

✓ **Consolidate results into one or more summary lists. Categorize results as determined appropriate (by problem type, known versus suspected, etc.).**

✓ **Compile supporting documentation for listed conditions.**

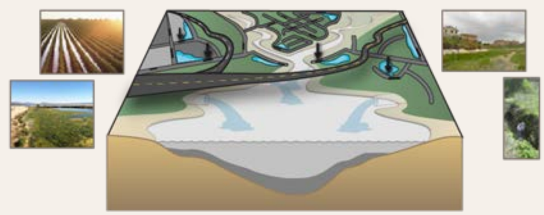
✓ **Document the critical data and information gaps identified during Task 2 completion.**

NOTES

Figure 4.4: Review Checklist for Defining Receiving Water Problems

Case Study 4.1 Linkages of Receiving Water Problems to MS4 and Source Contributions in a Drainage Area

In conducting Source and Impact Planning, it's helpful to consider a watershed scale example. Sources, MS4s, and receiving waters constitute a physically inter-connected system; pollutants and flows generated by watershed sources are transported by MS4s and eventually impact the condition of downstream receiving waters. This example illustrates how problem conditions observed for each of the three outcome levels can be related to each other.



Receiving Water Conditions

- *303(d) listings for eutrophication in the lower creek and estuary and sediment in the middle segment*
- *DO below water quality objective in creek and estuary*
- *Extensive algae in estuary during the summer*
- *Intermittent sediment toxicity and elevated pyrethroid concentrations*
- *Bioassessment data indicate benthic impairment*
- *Physical evidence of hydromodification in the creek*

Identified MS4 Contributions

- *MS4 outfall and agricultural runoff data indicate contributions of nutrients to receiving water above levels found in reference watersheds*
- *Data from construction site monitoring (SMARTS) show discharges of sediment*

Potential Source Contributions

A variety of residential and commercial sources exist in the watershed, but nutrient source identification studies indicate the highest loadings from agricultural runoff and groundwater. Sediment discharges are suspected from agricultural and construction sources.

Problem conditions for the MS4 outfalls and runoff from natural drainage channels are linked to eutrophication and decreases in dissolved oxygen levels in the receiving waters. Sources of nutrients causing eutrophic conditions can be confirmed as originating from agricultural runoff by comparing nutrient loadings from specific MS4 outfalls and contributing drainage areas. High total suspended solids in storm flows are potentially due to sediment loadings from constructions sites. As with many actual drainage area and watershed conditions, multiple potential problems coexist. It's currently unclear whether low DO, sedimentation, or pesticides are the primary causes of impairment to beneficial uses. Further delineation of MS4 and source contributions will also help to refine potential management options.

Task 3 Prioritizing Receiving Water Problems

Prioritization of receiving water problems is necessary in any instance where priorities are not already well-established, or where sufficient resources do not exist to address all identified problems. A structured prioritization process can also be useful for validating or refining existing priorities. The key questions described below are suggested to guide the prioritization of receiving water problems.

Step 6-A Task 3 Key Questions
Prioritizing Receiving Water Problems

Inputs	Key Questions	Outputs
Receiving Water Problems	**Question 1**: What is the priority rating of each receiving water problem? **Question 2**: What is the relative importance of each receiving water problem?	**Prioritized Receiving Water Problems**

As shown in **Figure 4.5**, prioritization is a two-step process. Each identified problem will first be reviewed to determine its **priority rating**. Ratings can then be considered together to determine their relative **priority ranking**. Managers may already have other preferred methods or approaches than those described here, and should choose those that work best for them. The process below is intended to apply across a variety of potential prioritization scenarios. It makes sense to explore a variety of potential scenarios, but it's also important to keep the number of potential receiving water priorities manageable.

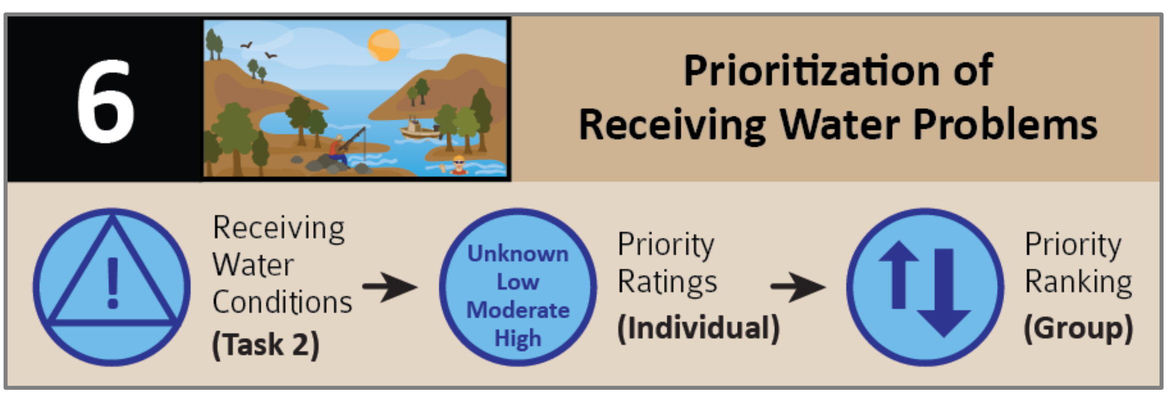


Figure 4.5: General Process for Prioritizing Receiving Water Problems

Question 1 What is the priority rating of each receiving water problem?

Prioritization starts with the assignment of a priority rating (e.g., Low, Moderate, or High Priority) for each receiving water problem. Assignment of ratings relies primarily on the review factors identified in Task 1 above. Their application to receiving water problems is described below. Potential "scores" for individual rating factors are indicated throughout for illustration, but managers should use any scoring methodology they find to be appropriate. As shown, simple qualitative scoring methods are recommended for each step of the process. Even where rating scores are derived from quantitative data, their application across different problem conditions can be extremely subjective.

Tier 1 Regulatory Screening

Receiving waters that are 303(d) listed, or that have adopted Total Maximum Daily Loads, must typically be treated as higher priorities. Other regulatory drivers can be limiting. For example, compliance with other state and federal laws (CEQA, 401 permits, Endangered Species Act, etc.) can constrain how or where resources may be directed, potentially impacting the controllability of a condition. Using a bacterial indicator as an example, **Figure 4.6** illustrates the Regulatory Screening process for a receiving water problem.

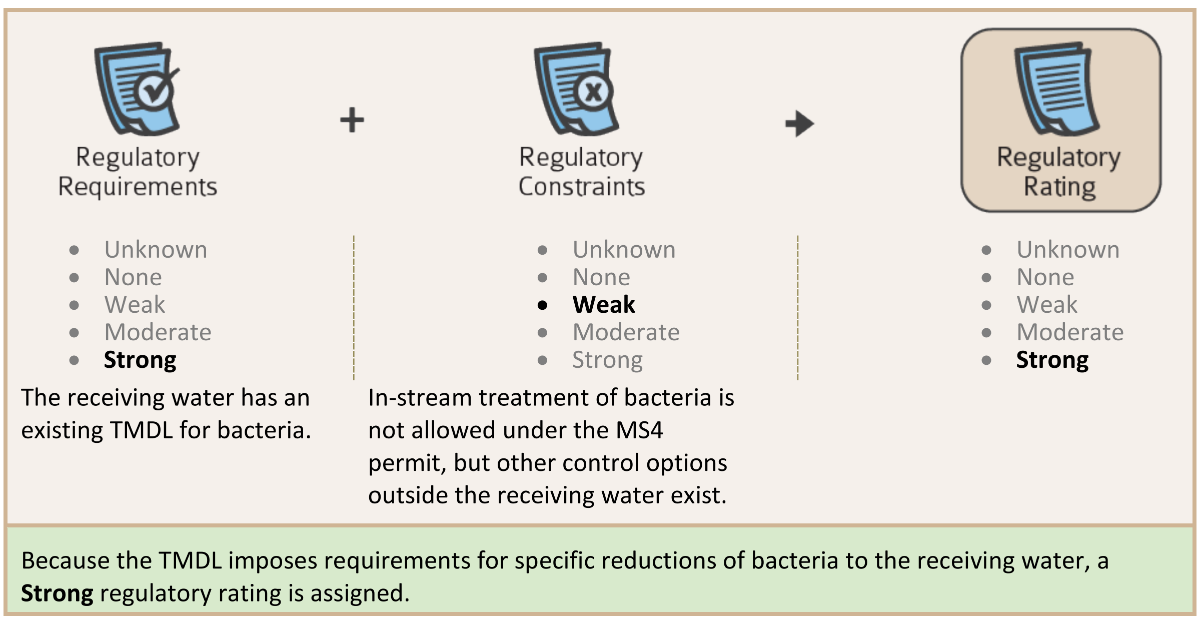


Figure 4.6: Establishing a Regulatory Rating for a Receiving Water Problem -- Bacterial Indicator Example[1]

[1] S = Strong, M = Moderate, W = Weak, N = None, U = Unknown. These are examples intended to illustrate potential rating designations.

It's important to note the direction of each applicable regulatory influence since some requirements and constraints can affect priority in opposite ways. If multiple regulatory factors are identified, their collective, and potentially offsetting, influence will need to be characterized. It may be difficult to modify a priority that is based on an absolute regulatory requirement. Even so, it makes sense to continue with other prioritization steps to ensure that all applicable evidence has been considered. When regulatory requirements conflict with other evidence, managers must maintain compliance, but may also need to advocate for additional study, flexibility or regulatory change.

Tier 2 Technical Review

Using the same example as above, a Technical Rating for each receiving water problem will now be determined. Technical Ratings are based on three factors; significance, certainty, and controllability. Ultimately, each condition must be interpreted in terms of consistent, categorical ratings (unknown, weak, moderate, etc.) that allow for their comparison. While this can sometimes lead to oversimplification, it is necessary to enable prioritization across a range of disparate types of conditions.

Significance is the cornerstone of the technical review process. The technical factors introduced in Task 1 above (nature, magnitude, and variability) combine to describe the significance of any receiving water problem. **Figure 4.7** illustrates the application of these factors using a bacterial indicator example. Potential rating scales are indicated for each review factor except for nature (which does not lend itself to standardized scoring).

Discretion is essential in scoring each factor since every problem condition is in some aspects unique. For example, rating the magnitude of a chemical concentration in a receiving water will be very different than assigning a rating for species abundance or diversity. Regardless, to gain a complete understanding of the problem condition, it's critical that each contributing factor be considered.

Certainty describes the confidence with which each receiving water problem condition can be asserted. Conclusions drawn on small samples or poor quality data can be misleading if they fail to adequately represent any contributing factor.

Controllability describes the potential to influence changes in the problem condition, primarily through changes in lower level outcomes. **Figure 4.8** illustrates how signficance, certainty, and controllability combine to establish a combined Technical Rating for a receiving water problem. Controllability is also considered further in **Case Study 4.2**.

Nature	Magnitude	Temporal Variability	Spatial Variability	Significance
	• Unknown • Low • **Moderate** • High	• Unknown • Low • Moderate • **High**	• Unknown • Low • Moderate • **High**	• Unknown • **Low** • Moderate • High
Bacterial indicators exceed water quality objectives, an indication of potential health risks to recreational users.	Most samples only slightly exceed standards.	Exceedances occur during 15% of sampling events.	Exceedances occur at 3 of 10 sampling locations.	

An overall significance of **Low** is indicated. Although human health risks are generally a significant concern, most exceedances are not of a high magnitude. The high variability of results also indicates that the problem condition is neither persistent nor widespread.

Figure 4.7: Receiving Water Problem Significance -- Bacterial Indicator Example

Significance	Certainty	Controllability	Technical Rating
• Unknown • **Low** • Moderate • High	• Low • **Moderate** • High	• Unknown • **Low** • Moderate • High	• Unknown • **Low** • Moderate • High
See **Figure 4.7** results.	Sampling has occurred at 10 stations over a two-year period. The spatial and temporal extent of the problem is moderately well-understood.	The potential for re-growth of bacteria in MS4s and receiving waters makes it difficult to limit their levels even when effective source controls are in place.	

Significance, certainty, and controllability combine to indicate an overall **Low** Technical Rating.

Figure 4.8: Establishing a Technical Rating for a Receiving Water Problem -- Bacterial Indicator Example

Case Study 4.2 A Closer Look at the Controllability of Dissolved Oxygen and TSS in a Stream and Estuary System

For the example introduced in **Case Study 4.1**, the measures needed to address DO levels observed in the estuary are not well understood. Nutrient reduction in dry weather flows and greater circulation in the estuary might address this problem, but the level of effort and feasibility of this strategy is not well defined. Moreover, if nutrient levels haven't been confidently established as the cause of the DO problem, solutions focusing on them might be misdirected. The controllability of nutrient levels in dry weather flows in the creek may also be rated as low. Factors other than nutrients (e.g., oxygen transfer, tidal flushing, etc.) can play a role in determining dissolved oxygen levels. In this case, the lack of clear linkages to a causative agent and identification of potential control measures might both be documented as data gaps and addressed in future data collection strategies.

The receiving water data that indicates TSS and turbidity levels above benchmarks in the wet weather flows are localized to areas with active construction. These data suggest potentially controllable sources as the cause of this localized impact. While the DO and nutrient issues in the stream and estuary are rated low for controllability, the TSS issue might be rated moderate or high.

Tier 3 Sustainability Review

Where possible, prioritization should also consider social and economic factors. **Economic factors** are essential because every problem and every proposed solution has one or more costs associated with it. This might, for example, include the cost of addressing the receiving water problem with current scientific knowledge and technology compared to the economic benefit achieved. **Social Impacts** are those related to target audiences, society at large, or other specific segments. Perceptions and opinions regarding specific receiving water problem conditions as well as acceptance of potential control strategies can strongly influence priority. The public generally expects to utilize and enjoy receiving waters, and can play an important role in instituting control measures to protect them.

Sustainability Ratings can be approached in either of two ways. Economic and social ratings may be developed individually, or a single combined rating may be developed for them together. Individual ratings would be a more likely choice in instances where managers want to give each factor greater overall weight to technical and regulatory factors. In most instances, knowledge of economic and social factors will be comparatively limited, so a single combined rating may be a more suitable choice.

Overall Priority Rating

As described in **Section 3.3 (Step A Task 3)**, Tier 1, 2, and 3 results are reviewed together to determine the **Overall Priority Rating** of each problem condition (**Figure 4.9**). Each rating is determined individually, i.e., independently of priorities for other conditions.

To determine a priority rating, the respective weightings of each of the results for each review tier must be considered. Although equal weightings have been assumed in this discussion for illustration, managers may want to determine their own approaches to the weighting and use of individual criteria and rating factors. Assigning weightings can be especially challenging given the fundamental differences in the nature of regulatory, technical, economic, and social factors. While it can sometimes be helpful to develop priority ratings using quantitative scoring methods, managers should bear in mind that prioritization approaches will still generally tend to lack precision. In most cases qualitative ratings are sufficient and appropriate. **Table 4.5** provides examples of the scoring of priority ratings for several receiving water problems.

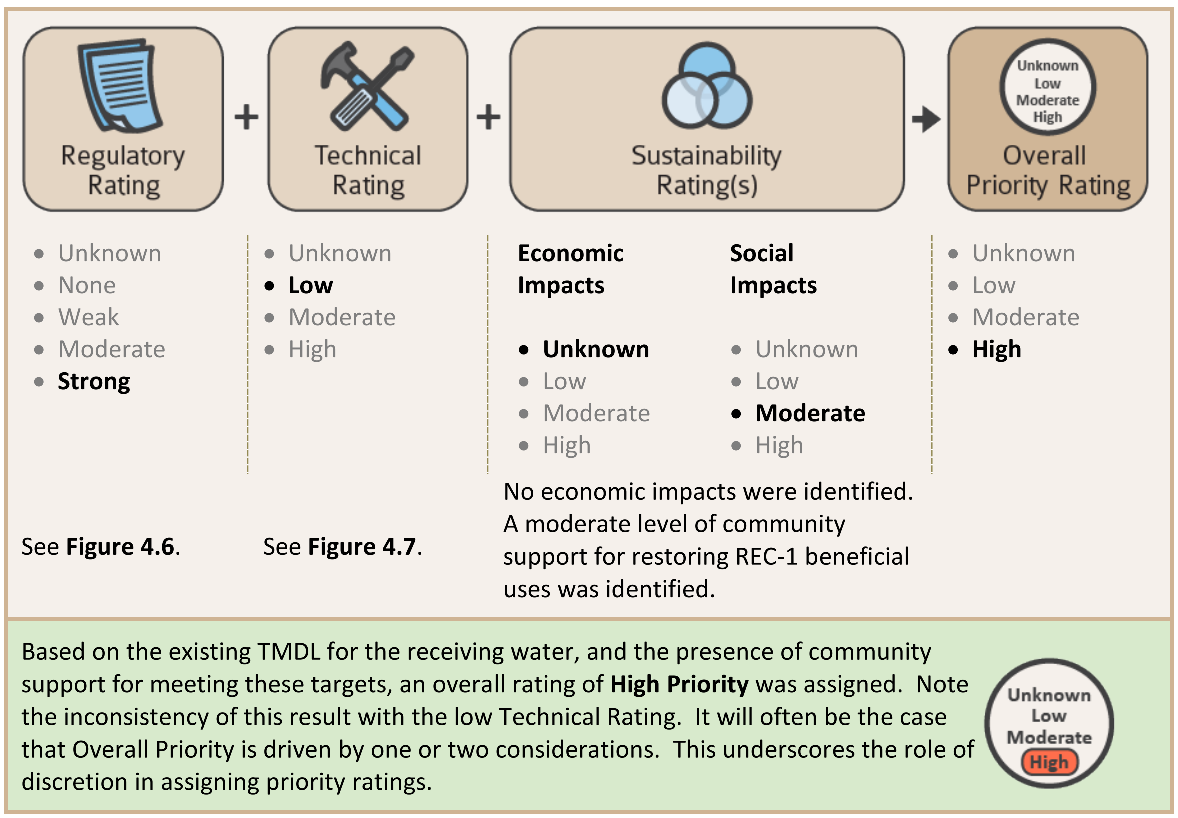


Figure 4.9: Establishing an Overall Priority Rating for a Receiving Water Problem -- Bacterial Indicator Example

Table 4.5: Examples[2] of the Assignment of Overall Priority Ratings to Receiving Water Problem Conditions

Problem Condition	Tier 1: Regulatory Screening	Tier 2: Technical Rating				Tier 3: Sustainability Ratings			Overall Priority Rating
		Significance	*Certainty*	*Controllability*	*Overall*	*Economic Factors*	*Social Factors*	*Overall*	
Chemical-Water Quality Problems									
TSS Concentrations above benchmarks in wet weather	**Strong**	Moderate	Moderate	Moderate	**Moderate**	Moderate	Low	**Low-Mod**	**Moderate**
Low DO levels in the estuary; 303(d) listing for eutrophication	**Strong**	Moderate	Moderate	Low	**Moderate**	Low	Moderate	**Low-Mod**	**Moderate**
Biological Problems									
Bacterial indicators exceed REC-1 standards	**Strong**	Low	Low	Low	**Low**	Unknown	Moderate	**Moderate**	**Moderate**
Bio-indicators show benthic impairment	**Strong**	Mod	Low	Low	**Low**	Low	Low	**Low**	**Low**
Toxicological Problems									
Bifenthrin above the LC50	**Unknown**	Moderate	Low	Low	**Low**	Low	Low	**Low**	**Low**
Physical Problems									
Physical evidence of hydromodification in creek	**Strong**	Low	Moderate	Moderate	**Moderate**	Moderate	Moderate	**Moderate**	**Moderate**

[2] These examples are hypothetical and for illustration only. They are not intended to imply a particular priority for any of the receiving water conditions listed.

Question 2 What is the relative importance of each receiving water problem?

For individual priority ratings to be useful in supporting decision-making, they must be evaluated together to determine their relative importance. Because programs must often address multiple receiving waters, considerations of scale are important. In some cases, managers will want to compare priorities across multiple receiving waters (e.g., copper exceedances in a river versus habitat degradation in an estuary); in others, they will want to prioritize conditions within a single receiving water or segment (e.g., copper exceedances versus habitat degradation in the same receiving water).

Using the examples of priority ratings presented in **Table 4.5**, two ranking options are illustrated in **Figure 4.10**. Identified problems can either be put into a ranked order or be grouped by their priority ratings. Establishing a **ranked order** consists of lining up the applicable problem conditions for each receiving water or segment from highest priority to lowest, with the higher priorities normally constituting the greater management priorities. A limitation to ranked order approaches is that receiving water problems may tend to have "tie scores". Using **grouped rankings** can reduce the need to conduct further analysis to differentiate between them.

Increasing Priority	RANKED ORDER EXAMPLE	GROUPED RANKING EXAMPLE
↑	1. Bacterial indicators exceed REC-1 standards 2. Low DO levels in estuary 3. Wet weather TSS above benchmarks 4. Hydromodification in creek 5. Benthic impairment 6. Bifenthrin toxicity	**GROUP A (Moderate)** • Bacterial indicators exceed REC-1 standards • Low DO levels in estuary • Wet weather TSS above benchmarks • Hydromodification in creek **GROUP B (Low)** • Benthic impairment • Bifenthrin toxicity

Figure 4.10: Potential Options for Ranking Receiving Water Problem Conditions

The final output of **Task 3** will be a ranked list of priority problem conditions for each receiving water or segment. It's important to keep the qualitative nature of this exercise in mind. Its purpose is simply to provide a method and informational basis for the comparison of different problem conditions. Rating and ranking systems, no matter how sophisticated, cannot replace judgment.

Figure 4.11 provides a Review Checklist to help guide the prioritization process. As in previous planning steps, significant data and information gaps are likely to be encountered along the way. It's important to document these deficiencies and consider them in the development of future data collection strategies.

Review Checklist

Step 6-A Task 3

Prioritizing Receiving Water Problems

Apply this task individually to all problem conditions identified in Task 2. Its purpose is to assess and rank the priorities of problem conditions.

✓ **For each identified problem condition, consider the following questions:**

Question 1: What is the priority rating of each receiving water problem?

☐ **Tier 1: Regulatory Screening** **REGULATORY RATING ________**

- ✓ Identify regulatory requirements and constraints affecting priority.
- ✓ Based on their collective impact, assign a Tier 1 rating.
- ✓ Note the overall direction of influence of the rating (requirement or constraint).
- ✓ Should an Overall Priority Rating be assigned based solely on regulatory criteria? If yes, stop and document. If no, continue to Tier 2 Review.

☐ **Tier 2: Technical Review** **TECHNICAL RATING ________**

- ✓ Evaluate the significance, certainty, and controllability of the problem. Establish individual weightings as appropriate for each of the three factors.
- ✓ Based on review of the above factors, assign a Tier 2 Rating.
- ✓ Should the problem be eliminated from further consideration or assigned a "low" Overall Priority Rating? If yes, stop and document. If no, continue to Tier 3 Review.

☐ **Tier 3: Sustainability Review** **SUSTAINABILITY RATING(S) ________**

- ✓ Identify economic factors and social factors affecting priority.
- ✓ Assign Tier 3 Rating (or Ratings) for economic and social factors.

☐ **Overall Priority Rating** **OVERALL PRIORITY RATING ________**

Collectively consider Regulatory, Technical, and Sustainability results to assign an Overall Priority Rating for each problem. Assign individual weightings to each factor as appropriate. Economic and Social factors may be counted individually or together.

Question 2: What is the relative importance of each receiving water problem?

☐ **Rank individual priority ratings for further consideration in Step B.**

✓ **Document the critical data and information gaps identified during Task 3 completion.**

NOTES

____

____

Figure 4.11: Review Checklist for Prioritizing Receiving Water Problems

Step 6 - B Targeted Receiving Water Changes

Step 6-B addresses the establishment of measurable targets for changes in receiving waters. This is a critical step toward the development of the control strategies needed to resolve identified problems. As shown in **Figure 4.12**, it consists of three tasks, each of which is explored below.

Figure 4.12: Targeting Receiving Water Changes (Step 6-B)

Step 6-B begins with the list of **Priority Receiving Water Problems** established at the completion of **Step 6-A**. Considering again the Receiving Water Data and Information gathered for each receiving water condition on the list (**Step 6-A Task 1**), one or more specific, measurable targets and timelines for change can be considered for each identified priority problem. In addition to helping direct programs toward the resolution of problems, this will establish a context for establishing measurability, interpreting results, and evaluating success over time.

Task 1 Identifying end-state targets

This task focuses on defining the changes to be sought in identified priority problem conditions. It is guided by two general questions.

Step 6-B Task 1 Key Questions
Identifying End-state Receiving Water Targets

Inputs	Key Questions	Outputs
Priority Receiving Water Problems	**Question 1**: What are the end-state receiving water conditions? **Question 2**: When will end-state receiving water conditions be achieved?	**End-state Receiving Water Conditions**

Question 1 What are the end-state receiving water conditions?

End-state receiving water conditions are those that represent the absence of problems, or their reduction to acceptable levels. Targets for change should be considered at least for the highest priority receiving water conditions identified above. The establishment of targets should consider the review factors and general conceptual approaches described below.

Review Factors

Several review factors have general applicability in setting targets for receiving water change. As shown in **Figure 4.13**, these are the same factors introduced above during problem prioritization.

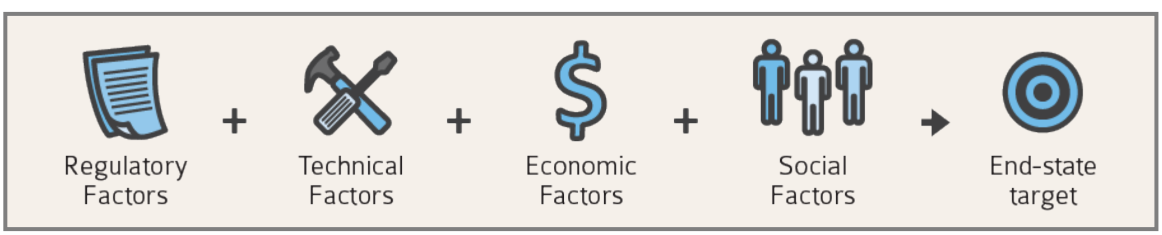


Figure 4.13: Factors Relevant to Setting Targets for Receiving Water Change

Draft targets can initially be established through a consideration of the regulatory and technical factors introduced above (see **Task 6-A-3**), and these results further reviewed and refined as necessary in the context of sustainability considerations. This process may need to be repeated multiple times as additional data and information become available.

General Approaches to Establishing End-state Receiving Water Targets

Targeting may follow any of the general approaches below, individually or in combination.

Setting Targets to Comply with Regulatory Requirements

Regulatory requirements often dictate the establishment of specific receiving water targets. This can be true in any case where a target is explicitly or implicitly defined in a permit or TMDL, e.g., compliance with Water Quality Objectives. Since regulatory directives often leave little room for interpretation, compliance with them must be maintained until other evidence can be obtained to support their revision or removal.

Setting Targets to Achieve Beneficial Use Protection

For receiving waters, the end-state condition will ideally be the attainment of specific beneficial uses. Since beneficial use attainment is a regulatory requirement, this approach can also be considered a subset of approach #1 above for receiving water changes. Where linkages are well-understood, it makes sense to target changes in receiving water conditions that will bring about attainment of these uses. This will typically be manifested as compliance with required load reductions or water quality objectives. It’s important to be realistic about the attainability of any targeted condition, even where it represents a strict regulatory requirement. It makes little sense to set targets that can’t be achieved. In cases where there the target itself is mandated, one option may be to set extended timeframes for achieving it, and to pursue interim targets that foster learning and adaptation along the way (see also approach #4 below).

Setting Targets to Resource Availability

Stormwater programs are rarely resourced to achieve all priority receiving water changes, so decisions must be made about how much and how quickly each of them can be reached. Individual targets established during planning should always reflect the sum of commitments being made, and the availability of resources to achieve them. It’s important to emphasize, however, that targets based solely on resource availability may often fail to meet explicit regulatory requirements, or to satisfy the expectations of regulators or third parties.

Setting Targets to Learn and Adapt

This approach involves establishing targets for lower level "causal" outcomes (MS4 load reductions, target audience behavioral changes, etc.) to explore their potential for bringing about receiving water changes. In practice, managers will often have little idea of what receiving water changes can realistically be achieved, or of the timeframes needed to reach them. Likewise, they often lack the knowledge base needed to understand to potential implications of specific management initiatives. Where large structural controls are being contemplated, specific receiving water targets and timeframes may be predicted with a greater degree of certainty. However, this is not usually the case since most changes are targeted through the implementation of a variety of non-structural source controls. As emphasized throughout this document, planning is often hampered by the availability or sufficiency of data and information. As such, it may instead make sense to implement programs with a general objective of learning through experience. As previously discussed, problem conditions are assumed to be sequentially linked in "chains" of cause and effect relationships. It follows that managers will benefit from exploring the potential implications of "dialing" a particular lower level outcome up or down. This "trial and error" approach relies heavily on the accumulation of experience and making adjustments through an adaptive management process.

Experimental targets foster adaptive management by establishing and exploring assumptions or hypotheses about relationships between receiving water conditions and other outcomes. For example, if managers have a good idea of the reductions in loadings of a particular pollutant that can be achieved in a watershed area, they might establish a working hypothesis about the receiving water changes they hope to see. By establishing and tracking measurements for both types of outcomes, they may be able to establish linkages to receiving changes over time.

One specific way of approaching this is through the establishment of **stretch targets**. Managers will often have a good idea of what type and degree of receiving water changes they've achieved in the past, and therefore where they may be able to build on existing commitments to leverage additional improvements. Building on existing accomplishments provides a means of "stretching" to see what can be done cost-effectively or within available resource commitments (note the similarity of this approach to approach #3 above). In doing so, managers can continue to actively learn while pursuing increases in measurability that might later be used to explore linkages.

Interim targets are also critical to the learning process because they provide opportunities for obtaining feedback along the way toward end-state conditions (e.g., interim periods over the life of a 25-year TMDL target). These targets are discussed further under **Task 2**.

Table 4.6 provides a variety of examples of potential end-state receiving water targets for priority receiving water problems previously identified in **Table 4.5**. The uncertainty associated with many of these targets should be noted as this is often a prominent feature of the targeting process.

Table 4.6: Examples[3] of End-state Receiving Water Targets

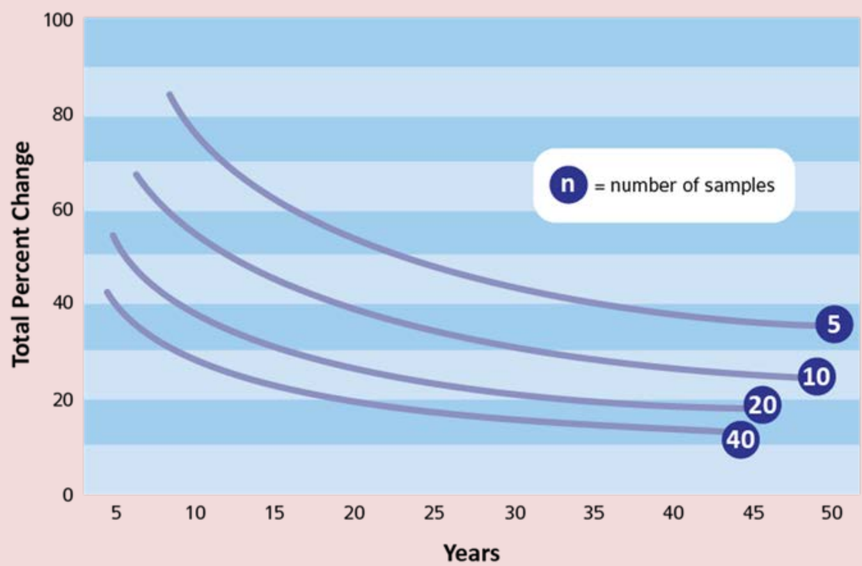
Problem Condition	Priority (from Table 4.5)	End-State Target	Explanation
Chemistry-Water Quality Priority Problems			
TSS concentrations and turbidity exceed benchmarks in wet weather	Moderate	Reduce TSS concentrations by 20%	20% reduction is targeted in combination with other programmatic stretch targets.
Low dissolved oxygen levels in creek	Moderate	Restore DO Levels to meet water quality benchmarks	Target is based on the direct linkage of the DO benchmark to beneficial use attainment.
Biological Priority Problems			
Benthic impairment in creek	Moderate	Achieve a bioassessment rating for a comparable reference site	Because the target is based on external conditions, its achievability may need to be determined over time.
Toxicity Priority Problems			
Toxicity from synthetic pyrethroid pesticide Bifenthrin	Low	Absence of toxicity from pesticide	An ideal target such as "no toxicity" may be achievable for some pollutants, such as pesticides, where adequate State and Federal authority are in place to control sources. For other pollutants for which statutory authority is lacking, such control may not be realistic.
Physical Priority Problems			
Physical evidence of erosion in creek	Moderate	Reduce peak flows and volumes	Target lacks a specific measurable endpoint or a timeframe. It might be initially approached experimentally with a goal of "filling in the gaps" through trial-and-error or ongoing evaluation of resource availability.

[3] These examples are hypothetical and for illustration only. They are not intended to imply a particular target or timeline for any of the receiving water conditions listed.

Key Concept 4.1 Variability and the Measurement of Receiving Water Changes

The inherent variability of most water quality parameters makes it extremely challenging to demonstrate improvements in receiving water quality over short periods. Based on a power analysis of wet weather receiving water data collected over a 5-10 year period in Southern California, this graph shows how many years it would take to verify various levels of change in water quality concentrations at a typical level of acceptable error (using a power of 80%). Each curve represents a different annual sampling frequency. For the data in this example, demonstrating a 40% change in water quality with 5 samples per year would require 35 years of sampling. Smaller changes (e.g., 10-20%), which would be more typical of those targeted by MS4 programs, would require substantially larger numbers of samples to verify, even within a 50-year horizon.

Since the sampling of stormwater flows is constrained by how many storms occur each year, a practical limitation exists on the potential for increasing sample size, leading to a conclusion that verification of targeted receiving water changes will generally require decades. This also underscores the need to focus on measurement of changes at other outcome levels (behaviors, source load reductions, etc.) over shorter time frames.



Courtesy of the County of Orange

Question 2   When will end-state receiving water conditions be achieved?

Every targeted change will ideally specify the timeframe needed to achieve it. As noted, some timeframes will already been established as permit or TMDL requirements. Numerical models (simple spreadsheets, complex numeric models, etc.) can be helpful for forecasting rates of potential change assuming specific implementation scenarios, but water quality and other receiving water conditions are highly variable. It's important to be realistic about how much time is needed to achieve and statistically define targeted changes. Targets for dry weather flows may often be more aggressive than wet weather flows that often require greater effort to achieve. For highly variable data sets, as is normally the case for both dry and wet weather receiving water conditions, the projection of end-state conditions based on small data sets or solely on measures of central tendency can be misleading.

As previously emphasized, end-state receiving water conditions can take decades to achieve (e.g., 20-50 years or longer; see **Figure 3.16**). Allowances should be made for the time it takes to "ramp up," refine, and fully implement the programs expected to drive these changes. There should be a point at which maximum gains can be expected, and possibly the acheivement of steady state conditions after that. Given this complexity, managers may often lack a basis for accurately forecasting specific timeframes, so their establishment up front may not always be possible. In such cases, timeframes can be established provisionally, and then reviewed and modified as additional data, information, and results become available.

Task 2 Establishing interim targets

Because of the extended timeframes typically needed to achieve end-state receiving water targets, it's important to establish incremental measures of progress. The establishment of interim targets is guided by two questions.

Question 1   What interim targets are needed to evaluate progress toward end-state receiving water conditions?

Interim targets are routinely established in TMDLs, and many MS4s permits are increasingly setting specific milestones for achieving change. They allow the assessment of incremental progress toward end-state conditions, and provide the feedback necessary for refining management approaches along the way.

Step 6-B Task 2 Key Questions
Establishing Interim Receiving Water Targets

Inputs	Key Questions	Outputs
End-state Receiving Water Targets	**Question 1**: What interim targets are needed to evaluate progress toward end-state receiving water conditions? **Question 2**: When will interim receiving water targets be achieved?	**Interim Receiving Water Targets**

Measurement of receiving water changes will often be based on constituent concentrations or pollutant loading trends evaluated over a timeframe where these targets are both measurable and acheivable. Managers should consider the specific targeted conditon, and the level of effort and resources available to address the problem. Where measurement is possible, interim targets should also reflect critical milestones in the "implementation curve" discussed under **Task 1** above. By obtaining feedback along the way, adjustments can be made along the way in response to early results.

Question 2 When will interim receiving water targets be achieved?

Timeframes for interim targets will be bounded by the schedule set for achieving the end-state condition, but will also reflect the need for specific feedback and ability to measure change along the way. For water bodies under a TMDL, or where MS4 permit conditions are prescriptive, interim targets may already be established.

Interim targets must account for the inherent variability of environmental data. Sampling over very short periods (e.g., 1-2 years) is unlikely to generate data that are useful for accurately characterizing receiving water changes. Interim targets should therefore be set to timelines that reflect both the time needed for changes to occur and for statistically valid measurement. Measurements less than five years from the implementation of targeted program activities will often be insufficient to detect change in receiving waters.

Where possible, strategies for measuring interim changes should incorporate sample sizes and timeframes that account for the variability of measurements within the receiving water. Likewise, they should reflect the time needed to achieve critical events in the projected "implementation curve" described above.

Task 3 Identifying Data Requirements

Once targets for receiving water change have been identified, it's necessary to identify how they will be measured, what data are needed to allow measurement, and how these data will be collected and analyzed. Planning is not complete unless managers are fully prepared to obtain and evaluate the data needed to assess targeted changes. The questions below should be addressed for each targeted outcome identified in **Step 6-B**.

Question 1   What metrics will be used?

End-state and interim receiving water conditions should both be expressed in unambiguous terms. This should include a specific formulation of the outcome statement, the assignment of units of measure or assessment, and units of time. **Section 7.3** provides additional detail on the establishment of metrics.

Question 2   What data collection methods will be used?

It's also essential that managers identify how data will be collected for each targeted receiving water outcome so that it can be tracked and assessed. **Section 7.4** provides additional detail on potential data collections options.

Question 3   What data analysis methods will be used?

The last consideration for any targeted receiving water outcome is how the data will be evaluated. The choice of analytical approaches and methods can dictate the specific metrics to be used, how data should be collected, and the quality of results. Where the establishment of receiving water data requirements cannot be satisfactorily addressed up front (e.g., there's no available option for collecting the desired data), this may need to be documented as a knowledge and data gap (Step 6-C). **Section 7.5** provides additional discussion of data analysis options.

Figure 4.14 provides a Review Checklist to guide **Step 6-B** completion.

Review Checklist

Step 6-B Tasks 1, 2, and 3

Targeted Receiving Water Changes

Apply this task individually to all conditions selected for targeting in Step 6-B. Its purpose is to identify specific targets for change in these conditions.

✓ **End-state Targets (Task 1)**
Consider the following questions:

Question 1: What is the end-state for the problem condition?
Question 2: When should the end-state condition be achieved?

✓ **Interim Targets (Task 2)**
Consider the following questions:

Question 1: What interim targets are needed to evaluate progress toward the end-state condition?
Question 2: When will interim targets be achieved?

✓ **Data Requirements (Task 3)**
Consider the following questions:

Question 1: What metrics will be used?
Question 2: What data collection methods will be used?
Question 3: What data analysis methods will be used?

✓ **For each priority receiving water problem, document interim and end-state targets, and the data requirements necessary to track and evaluate them.**

✓ **Compile one or more lists of targeted receiving water changes and supporting documentation for listed conditions.**

✓ **If a priority receiving water change is not or cannot be targeted, document the reason.**

✓ **Document all Step B data and information gaps.**

Figure 4.14: Review Checklist for Targeting Receiving Water Changes

Step 6 - C Documenting Knowledge and Data Gaps

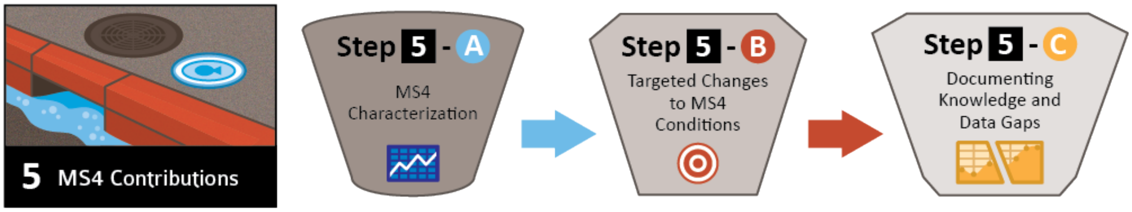
The identification of knowledge and data gaps should be ongoing throughout the entire Level 6 planning process. At its conclusion, managers should have developed a list of gaps that can be incorporated into an assessment strategy. **Section 7.0** provides additional guidance on assessment tools and strategies to support the development of these strategies. Because a comprehensive existing baseline of data and information does not usually exist for all receiving water conditions, Level 6 knowledge and data gaps can be significant. Critical gaps must be addressed to ensure that they are resolved over time. **Table 4.7** provides examples of general areas of inquiry where Level 6 knowledge and data gaps are likely to be encountered. These are intended to provide a framework for identifying actual knowledge and data gaps, which will be much more specific than those listed here.

Table 4.7: Potential Areas of Receiving Water Knowledge and Data Gaps

✓ Understanding of receiving water conditions (nature, magnitude, variability, and trends)
✓ Adequacy of sampling data (sample size, representative sampling, etc.)
✓ Adequacy of sampling methodologies
✓ Adequacy of beneficial use designations
✓ Adequacy of water quality objectives, regulatory criteria, etc.
✓ Adequacy of 303(d) listings
✓ Knowledge of regulatory requirements and constraints affecting receiving waters
✓ Knowledge of economic and social factors affecting receiving waters
✓ Methodologies, criteria, and data support for conducting problem identification
✓ Methodologies, criteria, and data support for conducting prioritization

4.3 Outcome Level 5: MS4 Conditions

Level 5 planning is a three-step process.



In **Step 5-A**, existing data and information are reviewed to evaluate MS4 conditions and identify priority problems. **Step 5-B** focuses on defining changes to be sought. **Step 5-C** identifies knowledge and data gaps to be addressed in future data collection initiatives.

As shown in **Figure 4.15**, MS4 characterization consists of three tasks. Characterization begins with a review of available data and information applicable to MS4 conditions.

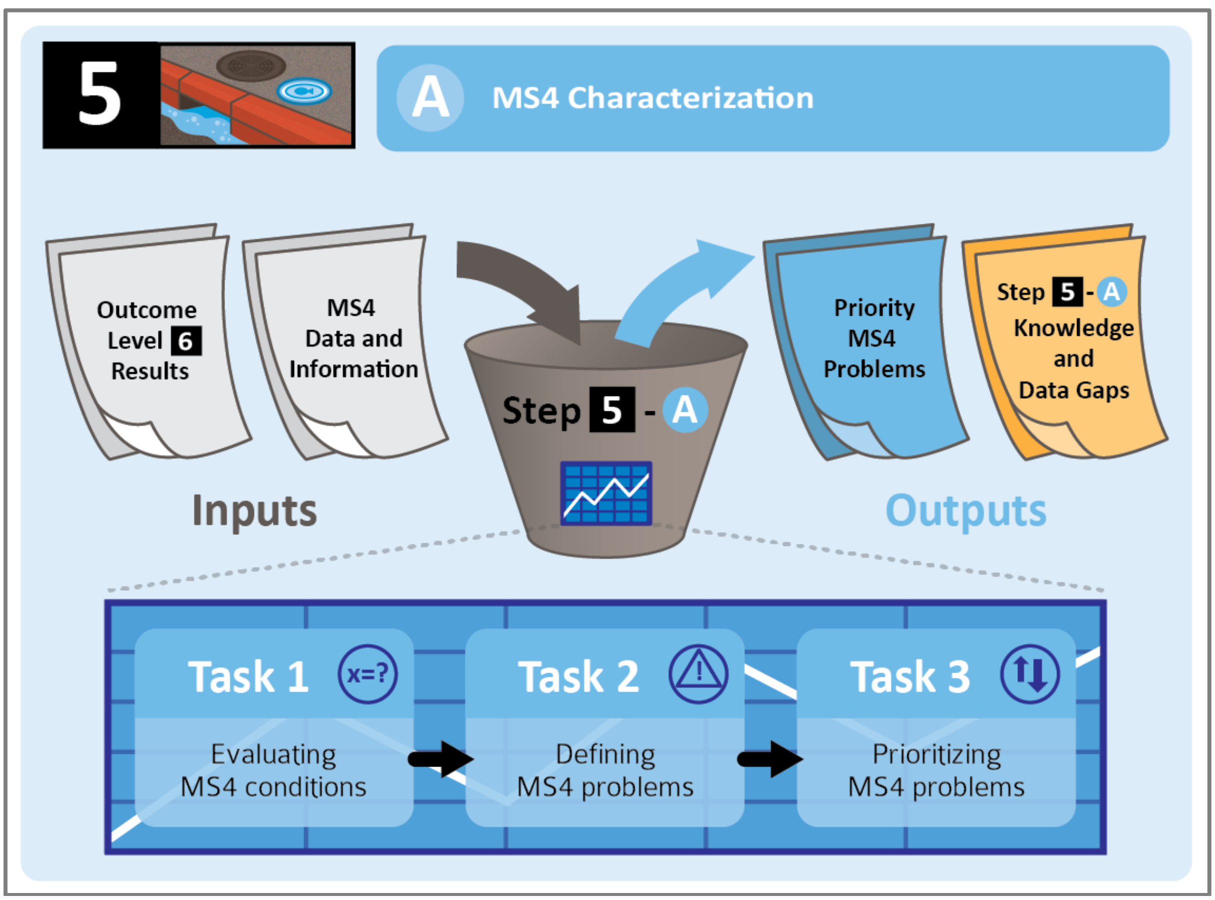


Figure 4.15: MS4 Characterization (Step 5-A)

Table 4.8 identifies a variety of data and information resources that can be used to inform Level 5 strategic planning. This includes Level 6 planning results, monitoring and maintenance data collected by the MS4 program, and a variety of external sources such as other regulatory agencies, research institutions, and published research.

Table 4.8: Potential Sources of Data and Information for Level 5 Planning

Outcome Level 6 Results (from Section 4.2)
Step 6-A
☑ Receiving water characteristics (Step 6-A; pollutant loadings, hydrology, etc.)
☑ Beneficial use designations
☑ CWA Section 303(d) listings
☑ Total maximum daily loads (TMDLs)
Step 6-B
☑ Priority receiving water problems (e.g., constituents, stressors, impacted segments)
Step 6-C
☑ Outcome Level 6 knowledge and data gaps
MS4 Data and Information
☑ MS4 monitoring program sampling data and reports
☑ MS4 maintenance inspections
☑ Regulatory agencies and research institutions (SCCWRP, WERF, etc.)
☑ Online repositories, directories, and databases (CERES, SWAMP, etc.)
☑ Published or unpublished research, literature, and technical reports
☑ Special investigations
☑ Other (as needed)

Task 1 Evaluating MS4 Conditions

Following on the results of Level 6 planning, managers will next identify and evaluate data and information relating to the MS4s under their responsibility and control. At this point the field of inquiry should be defined very broadly to include all potential facilities and conditions. Evaluations will address two key questions.

Step 5-A Task 1 Key Questions
Evaluating MS4 Conditions

Inputs	Key Questions	Outputs
Available Data, Information, and Results	**Question 1:** What are current MS4 conditions? **Question 2:** How are MS4 conditions changing over time?	**Existing MS4 Conditions**

Question 1   What are current MS4 conditions?

A **MS4** is a conveyance or system of conveyances, including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains. Stormwater runoff is commonly transported through MS4s and often discharged untreated into local waterbodies. MS4s are the means by which pollutants and flows generated in upland drainage areas are conveyed to receiving waters. The term MS4 can represent an entire conveyance system, or specific segments or portions of it. It's critical that managers understand how specific conditions within them affect the quantity and quality of these discharges. The more they know about how these conditions vary within specific portions of the MS4 the greater their ability will be to design specific targeted program approaches. A comprehensive understanding of MS4 conditions is also essential to developing baselines from which changes can be targeted.

Nature and Magnitude

The **nature** (i.e. general characteristics or attributes) of conditions within or discharging from MS4s is often similar to those already discussed for receiving waters (see **Step 6-A, Task 1**). As shown in **Table 4.9**, they can also be grouped according to the same general categories. MS4 characterization often focuses on constituent monitoring because urban areas generate a wide variety of pollutants that can be transported to receiving waters. Flow volumes, rates, and durations within and exiting these systems are also of interest both because they carry contaminants and because of their potential for contributing to hydromodification impacts in receiving waters. Other conditions such as toxicity, the presence of trash, or the physical condition of the MS4 itself, can also be of interest.

Table 4.9: General Types and Examples of MS4 Conditions

Type of Condition	Examples
Chemical Conditions	
Constituents in flows (wet, dry, and ambient)	• Chemical constituent concentrations or loads (metals, pesticides, nutrients, etc.)
Biological Conditions	
Pathogens and indicators	• Bacterial indictors in wet and dry weather flows • Pathogens (bacteria, viruses, protozoa, etc.) in wet and dry weather flows
Toxicological Conditions	
Toxicity of discharges from MS4 outfalls	• Metals, pesticides, nutrients, etc.
Physical Conditions	
Physical condition of MS4 facilities (channels, streets, roads, inlets, outlets, etc.)	• Geomorphic conditions • Erosion and sedimentation • Structural integrity • Extent and amount of trash
Flow conditions within the MS4 and from outfalls	• Presence or absence, volume, velocities, and durations of flows
Other	• pH, temperature, conductivity, dissolved oxygen, turbidity

Many permit programs require MS4 outfall monitoring. This typically includes dry weather flow monitoring and wet weather flow and chemical constituent analysis. Characterization of MS4 contributions will ideally include data that represent ongoing contributions and that are characteristic of sources within contributing drainage areas. Monitoring data that are focused on the identification and elimination of illicit discharges can also be useful for focused investigations, but may not be broadly representative of source contributions.

Magnitude (i.e., dimension or scale) is also critical to a complete understanding of MS4 conditions. To understand potential impacts and likely sources, managers generally need to know the levels of pollutants (e.g., average concentrations) and flows (volumes, peak velocities, etc.) within or discharging from the MS4. Together, nature and magnitude provide a basic description of each MS4 condition. It’s also necessary to consider how they vary in time and space.

Variability

Variability refers to how spread apart the measurements in a distribution are, or how they vary from each other temporally or spatially. The **temporal variability** of MS4 conditions can be significant over various periods (daily, seasonally, etc.). Occasional exceedances of a benchmark within one segment of the MS4 will likely represent a lesser priority than persistent exceedances throughout the system. Many stormwater programs have already conducted various levels of MS4 and urban runoff characterization monitoring. These results may provide a basis for understanding existing patterns. Some MS4 conditions vary according to regular patterns. For example, inputs of flows into MS4 systems will normally vary significantly by season, making it necessary to evaluate MS4 conditions independently for wet and dry weather. Likewise, patterns of activity within the watershed (early morning watering, weekend car washing, etc.) can produce patterns in flows or pollutant generation on daily or weekly cycles.

The **spatial variability** of conditions is especially critical in MS4s. MS4s are complex networks of drainages, and conditions within them can vary widely. Discharges from individual outfalls will be highly variable depending on the characteristics of the system itself and of the drainage areas contributing flows to it. To enable the development of targeted management approaches, it's important to define not only the contribution of the MS4 as a whole, but also which segments and outfalls represent the greatest contributions to receiving water impacts. It's therefore critical that specific, detailed relationships between receiving waters, MS4 outfalls, and drainage areas be established. A good understanding of the spatial distribution of MS4 conditions can provide a basis for establishing and refining these linkages.

Depending on the size and number of outfalls, characterization can be approached through a statically random sampling plan based on parameters such as land-use, outfall size, drainage area, or a combination. However, this may not always be useful in identifying the highest contributing outfalls to receiving waters. A combination of random and targeted monitoring approaches may be useful in helping to identify specific outfalls persistently discharging non-stormwater or stormwater.

Nature, magnitude, and temporal and spatial variability together define the **significance** of a MS4 condition. Along with other factors considered below, significance plays an important role in determining whether or not a MS4 condition will later be classified as a problem.

Certainty and Controllability

Certainty is the degree of confidence that managers have in their assessment of each MS4 condition. While many dry weather MS4 conditions are easily observed or measured, managers should be wary of results that are based on limited sampling. Where possible, evaluation should include statistical analysis of data over periods sufficient to determine trends, range, mean and variance within desired confidence levels. Due to the high variability of most water quality data, statistically sound support for management decisions can only be developed if appropriate timeframes for achieving and measuring change in MS4s are incorporated. Data and information gaps can heavily influence certainty. It's important to continue characterizing MS4 conditions that are initially not well understood, or that demonstrate significant variability.

Controllability is the potential for a program to influence changes in a MS4 condition. The degree to which a MS4 condition can be controlled directly affects its likelihood of positively influencing receiving water improvements. For example, if the condition is the presence of trash or debris in a particular segment of the MS4, it might be controlled through increased maintenance or volunteer clean-ups. However, elevated levels of bacteria in dry weather flows could be considerably more difficult to control. In instances like these where flows or materials cannot be treated, diverted, or removed, the controllability of conditions within the MS4 tends to be much lower. In these cases, management strategies must reflect an understanding of contributing sources and the presence of viable source control options for them. In both instances, costs and program resources also directly influence controllability.

Question 2   How are MS4 conditions changing over time?

Trends are increases, decreases, or other measurable changes in a condition over time. For example, increases in sediment or trash accumulation or pollutant loadings in the MS4 due to urbanization. In addition to understanding the inherent variability of MS4 conditions, it's important to know whether they are trending upward or downward over time (e.g., in response to population increases, program implementation, or aging of the MS4 itself). Trend analysis can be a very powerful tool for interpreting outcomes and describing change. It's especially important to know if trends in MS4 conditions are correlated to changes in receiving water conditions. To support the evaluation of changes, it's important that a baseline of existing conditions be established, and that changes in key parameters are tracked over time.

The output of **Task 1** will be the documentation of a variety of MS4 conditions. Lists may be generated for the MS4 as a whole, or for individual segments or portions of it. They may also be segregated by conditions within the MS4 and those discharging from it. Results should be as inclusive as possible given the availability of supporting data and information.

Because of the many-to-one relationship of MS4 conditions to receiving waters, it's also important to keep the number of potential conditions manageable. Where data are insufficient to fully describe a condition, knowledge and data gaps should be documented for consideration in future data collection strategies. Identification of MS4 problem conditions will occur in **Task 2**.

Figure 4.16 provides a Review Checklist to guide **Task 1** completion.

Review Checklist

Step 5-A Task 1

Evaluating MS4 Conditions

Apply this task very broadly across all sources of data and information for MS4s. The purpose is to provide a "snapshot" of what is currently known about MS4 conditions.

✓ **Compile existing MS4 data, information, and results.**
Consider the following questions:

Question 1: What are current MS4 conditions?

Consider: Nature, magnitude, temporal and spatial variability, certainty, controllability, and trends

Question 2: How are MS4 conditions changing over time?

Consider: Variability and trends

✓ **Consolidate results into one or more summary lists of existing conditions. Categorize results as determined appropriate (by location, drainage area, facility type, etc.).**

✓ **Compile supporting documentation for listed conditions.**

✓ **Select the conditions in the summary list(s) that will be further evaluated as potential problems in Task 2. Consider "back-up" lists for future evaluation as necessary.**

✓ **Document the critical data and information gaps identified during Task 1 completion.**

NOTES

Figure 4.16: Review Checklist for Evaluating MS4 Conditions

Task 2 Defining MS4 Problems

The objective of this task is to determine which of the MS4 conditions identified above constitute problems. Two key questions guide this evaluation process.

Step 5-A Task 2 Key Questions
Defining MS4 Problems

Inputs	Key Questions	Outputs
Existing MS4 Conditions	**Question 1:** Does the MS4 condition contribute to a receiving water impact? **Question 2:** Is there independent evidence for designating the MS4 condition as a problem?	**MS4 Problems**

Question 1 Does the MS4 condition contribute to a receiving water impact?

For MS4 contributions, the most direct expression of a problem condition will be a demonstrated linkage to a priority receiving water problem. Evaluation of potential linkages should be based on a comparison of available data for both sets of conditions. Where supported, managers should first look for commonalities such as constituent matches (chemical constituents, bacterial indicators, etc.), toxicity, or physical conditions (erosion and sedimentation, flow rates, etc.). Where qualitative matches exist, evidence of causal linkages can be further explored over time. Establishing linkages between outcome types can be one of the most challenging aspects of the evaluation process. The detection of a constituent match alone may not indicate a causal linkage, so additional evidence such as comparisons of concentrations or loads, or the timing of discharges, should be considered. The evaluation of physical conditions can also be relevant. For example, evidence of bank erosion, channel incising, and habitat impact within a receiving water can be compared to flows at MS4 outfalls or conditions within channels or drainage areas.

Where evidence of a MS4 problem condition does exist, it may not be final or absolute. Conclusions are only as valid as the data they're built on. Managers should remain cognizant of the need to consider the most currently available data and analysis. Likewise suspected linkages to receiving water impacts may require confirmation through additional sampling and analysis. Resource commitments to MS4 problems that are not supported by statistical analysis or other corroborating evidence should be made with caution.

Question 2 Is there independent evidence for designating the MS4 condition as a problem?

Where receiving water conditions do not provide an objective point of reference for identifying causally linkages, MS4 problem conditions may also be identified through other independent lines of evidence. For example, if copper is detected in MS4 outfalls from several residential communities, but not identified as impacting the receiving water, managers might still consider other evidence to determine if this represents a potential problem. Do copper levels in the MS4 consistently exceed established action levels or other established regulatory benchmarks? Are they outside the norm or higher than at outfalls in other similar drainage areas or land uses? Does experience show similar levels to be problematic elsewhere? Investigation of these and other relevant questions might indicate the presence of a problem condition, or of a potential future problem. The same is true for most other measurable parameters (toxicity, trash, erosion, etc.).

The output of **Task 2** will be one or more lists of MS4 problem conditions. This will constitute a subset of the list or lists generated for **Task 1** above. Results may include a range of confirmed or potential problems. Where data are insufficient to reasonably confirm a condition as a problem, it may be listed as tentative and identified knowledge and data gaps considered for future data collection strategies. Prioritization of problem conditions will occur in **Task 3** below.

Figure 4.17 provides a Review Checklist to guide **Task 2** completion.

Review Checklist

Step 5-A Task 2

Defining MS4 Problems

Apply this task individually to each Task 1 MS4 condition selected for further evaluation. The purpose of this task is to determine which of these conditions should be designated as problems.

✓ **For each identified condition, consider the following questions:**

Question 1: Does the MS4 condition contribute to a receiving water impact? If no, or if unknown, continue to Question 2.

Consider the following:

- Constituents common to receiving water problems (esp. for 303(d) listings or TMDLs)
- Exceedances of water quality objectives at outfalls
- Volumes, velocities, and durations of flows within and discharging from the MS4

Question 2: Is there independent evidence for designating the MS4 condition as a problem?

Consider the following:

- Exceedances of Action Levels, or other applicable criteria
- "Reference" conditions in other MS4 segments or outside the area of investigation

✓ **Document known or suspected MS4 problem conditions.**

✓ **Consolidate results into one or more summary lists. Categorize results as determined appropriate (by problem type, known versus suspected, etc.).**

✓ **Compile supporting documentation for listed conditions.**

✓ **Document the critical data and information gaps identified during Task 2 completion.**

NOTES

Figure 4.17: Review Checklist for Defining MS4 Problem Conditions

Task 3 Prioritizing MS4 Problems

Starting with the list of MS4 problem conditions identified above, further review can help to determine the highest priorities for action or additional study. A structured prioritization process can also be useful for validating or refining existing priorities. Two key questions guide the prioritization of MS4 problems.

Step 5-A Task 3 Key Questions
Prioritizing MS4 Problems

Inputs	Key Questions	Outputs
MS4 Problems	**Question 1:** What is the priority rating of each MS4 problem? **Question 2**: What is the relative importance of each MS4 problem?	**Prioritized MS4 Problems**

Prioritization of MS4 conditions is a two-step process (**Figure 4.18**). Each problem is first reviewed to determine its **priority rating**. Ratings are then considered together to determine their relative **priority ranking**. Managers may already have other preferred approaches than those described, and should choose those that work best for them.

Because MS4s normally exist in a many-to-one relationship with receiving waters, it's important to remember that a considerable number of individual priorities may be possible. For example, consider a very simple scenario where a single receiving water segment receives dry weather flows from ten MS4 outfalls. One approach might be to prioritize the contribution of each outfall (e.g., based on the magnitude of flows or pollutants); another would be to establish priorities for some or all of them as a group (grouped on outfall size, rates of flow, etc.). Another typical scenario is that multiple problem conditions will be identified at a single outfall or within a single MS4 segment, i.e., elevated levels of bacteria and of copper. In this case, managers will want to determine the relative importantance of each condition to that particular segment.

There is no single "right" approach to prioritization. In establishing MS4 priorities, managers will likely want to explore a variety of potential scenarios. But in doing so, it's important to keep the number of potential priorities manageable.

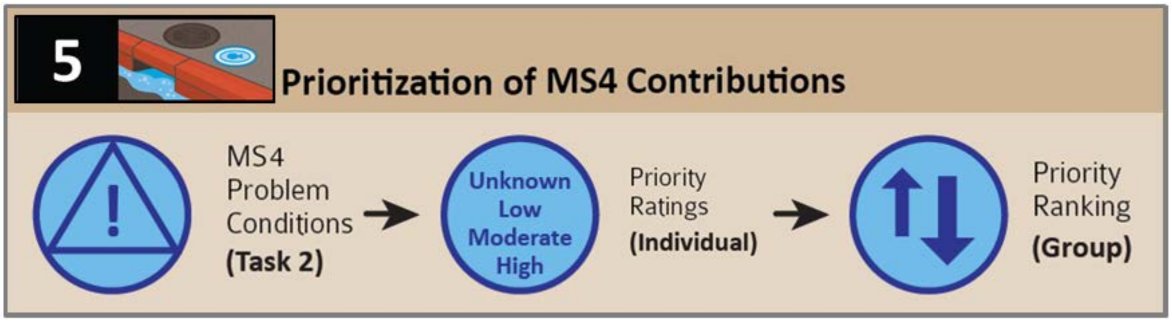


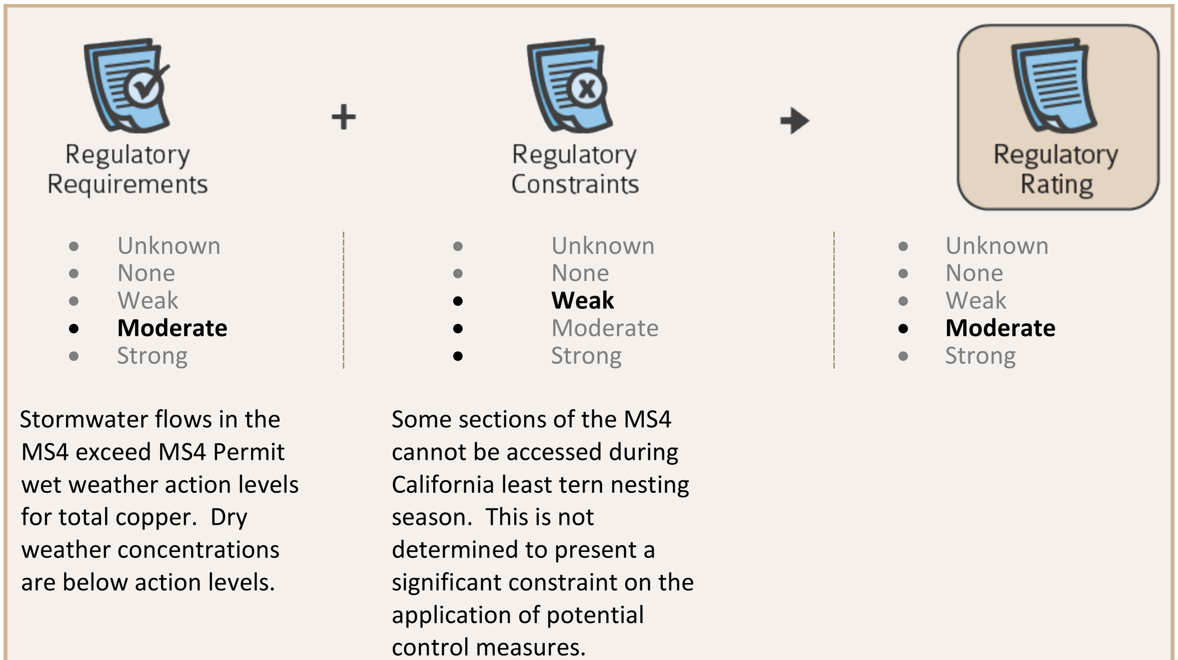
Figure 4.18: General Process for Prioritizing MS4 Problems

Question 1 What is the priority rating of each MS4 problem?

Prioritization starts with the assignment of a priority rating (e.g., Low, Moderate, or High Priority) for each identified MS4 problem. Assignment of ratings relies primarily on the review factors identified in Task 1 above. Their application to MS4 problems is described below. Potential "scores" for individual rating factors are indicated throughout for illustration, but managers should use any scoring methodology they find appropriate. As shown, simple qualitative scoring methods are generally recommended for each step of the process.

Tier 1 Regulatory Screening

Using copper exceedances as an example, **Figure 4.19** illustrates the Regulatory Screening process for a MS4 problem.



A **Moderate** rating is based primarily on the exceedance of wet weather action levels, which implies a potential receiving water impact.

Figure 4.19: Establishing a Regulatory Rating for a MS4 Problem – Copper Example

MS4 conditions that exceed defined regulatory criteria (stormwater action levels, WQBELs, etc.), or that can be directly linked to 303(d) listings or adopted Total Maximum Daily Loads, will typically be treated as higher priorities. Compliance with other directives such as permitting or mitigation requirements or seasonal restrictions on maintenance work can also constrain how or where program activities can be directed. As previously noted, the direction of regulatory influences is important since requirements and constraints can affect priority in opposite ways. Where applicable, the collective influence of multiple regulatory influences may also need to be considered.

Tier 2 Technical Review

Using the same example, a Technical Rating for each MS4 problem can be determined. Technical Ratings are based on three factors; significance, certainty, and controllability.

Significance is the importance or meaning of the MS4 condition. As shown in **Figure 4.20**, the nature, magnitude, and temporal and spatial varibility of a condition help to determine its significance. Potential rating scales are indicated for each review factor except for nature, which is too varied to assign a standardized rating.

Nature	Magnitude	Temporal Variability	Spatial Variability	Significance
	• Unknown • Low • Moderate • **High**	• Unknown • Low • **Moderate** • Low	• **Unknown** • Low • Moderate • High	• **Unknown** • **Low** • Moderate • High
Stormwater flows within the MS4 exceed permit wet weather action levels for total copper.	Average levels are three times the action level and exceed water quality objectives for the downstream receiving water.	Action levels are exceeded in 40% of sampling events.	Sampling is confined to only a minor portion of the MS4.	

The high magnitude of the exceedances may indicate a significant problem. But the distribution of the condition is not clear. This condition might either be rated as **Low** significance or alternatively as **Unknown** until additional sampling can verify its distribution.

Figure 4.20: Evaluating the Significance of a MS4 Problem – Copper Example

Certainty describes the confidence with which a MS4 problem condition can be asserted. MS4 problem conditions that are characterized with a low degree of certainty (e.g., conclusions drawn on small sample sizes) will generally not be priorities for resource allocations. **Controllability** describes the potential to influence changes in the problem condition, primarily through changes in lower level outcomes. Conditions that do not have a reasonable chance of being successfully controlled (e.g., areas of the MS4 that tend to "incubate" bacterial indicators) are also unlikely to emerge as high priorities. **Figure 4.21** illustrates how significance, certainty, and controllability combine to establish a combined Technical Rating for a MS4 problem.

Tier 3 Sustainability Review

Economic factors are essential because every problem and every proposed solution has one or more costs associated with it. This might, for example, include the cost of addressing the MS4 problem with current scientific knowledge and technology compared to the economic benefit achieved. Or the costs of building and operating BMPs within the MS4. **Social factors** focus on the role or value of MS4 facilities, or potential solutions, to local communities or society at large. For example, individuals within a community might or might not support the proposed construction of facilities or controls within the MS4.

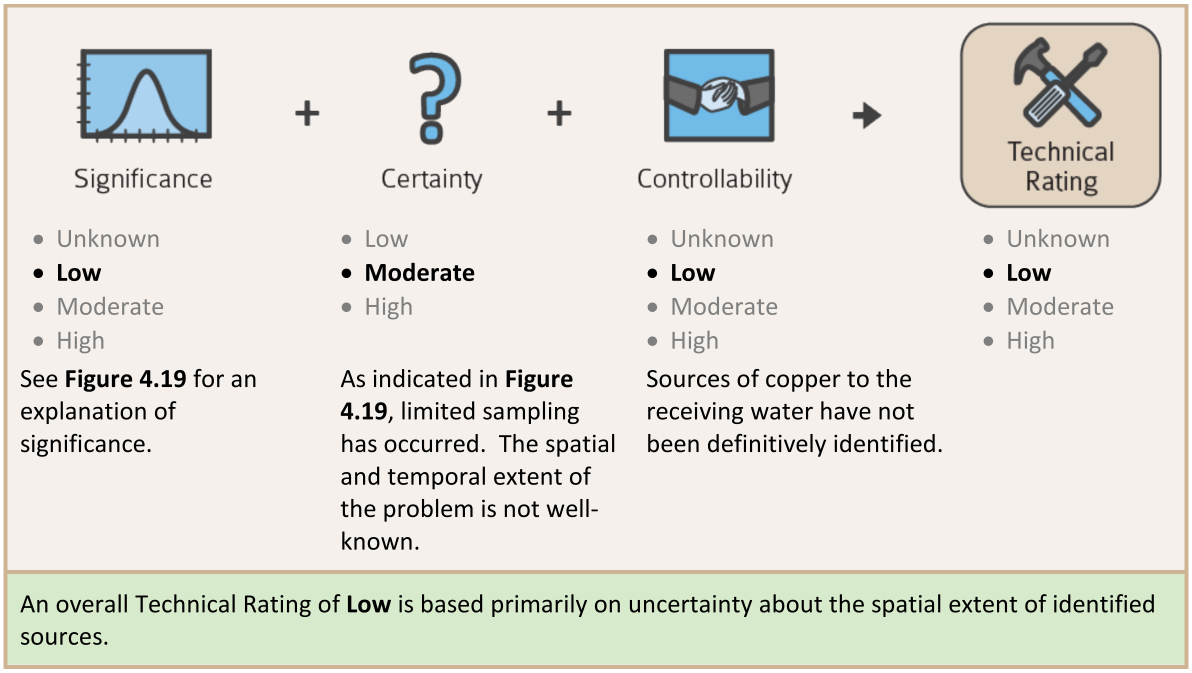


Figure 4.21: Establishing a Technical Rating for a MS4 Problem – Copper Example

Likewise, local residents often have strong opinions about other source control options such as increasing surveillance of homeless populations in or around MS4s. Economic and social ratings can be developed individually, or a single combined rating may be developed for them together. In most instances, detailed knowledge of economic and social factors associated with MS4 conditions will be lacking, so a single combined rating will be a suitable choice.

Overall Priority Rating

Tier 1, 2, and 3 results are next reviewed together to determine the **Overall Priority Rating** of each MS4 problem condition. A rating should be assigned for each condition.

Following on the example described above, **Figure 4.22** illustrates the determination of an Overall Priority Rating for exceedances of Wet Weather Action Levels for copper at MS4 outfalls. In this case, the Overall Priority Rating of Low is consistent with each of the individual sub-rankings used to determine it. In cases where individual factors are of different magnitudes or weigh in opposite directions (i.e., offset each other), discretion will be needed in assessing their collective impact.

Table 4.10 provides additional examples of the scoring of Overall Priority Ratings for other MS4 problem conditions. These examples are intended to illustrate a scoring process. The qualitative nature of the evaluation should once again be emphasized. To keep the exercise simple, equal weightings of rating factors have been assumed, but managers may also choose different weightings. Likewise, it should be emphasized that the results of each step in this process are subjective. Results are highly dependent on discretion, as well as the quality and availability of data and information at the time of the evaluation.

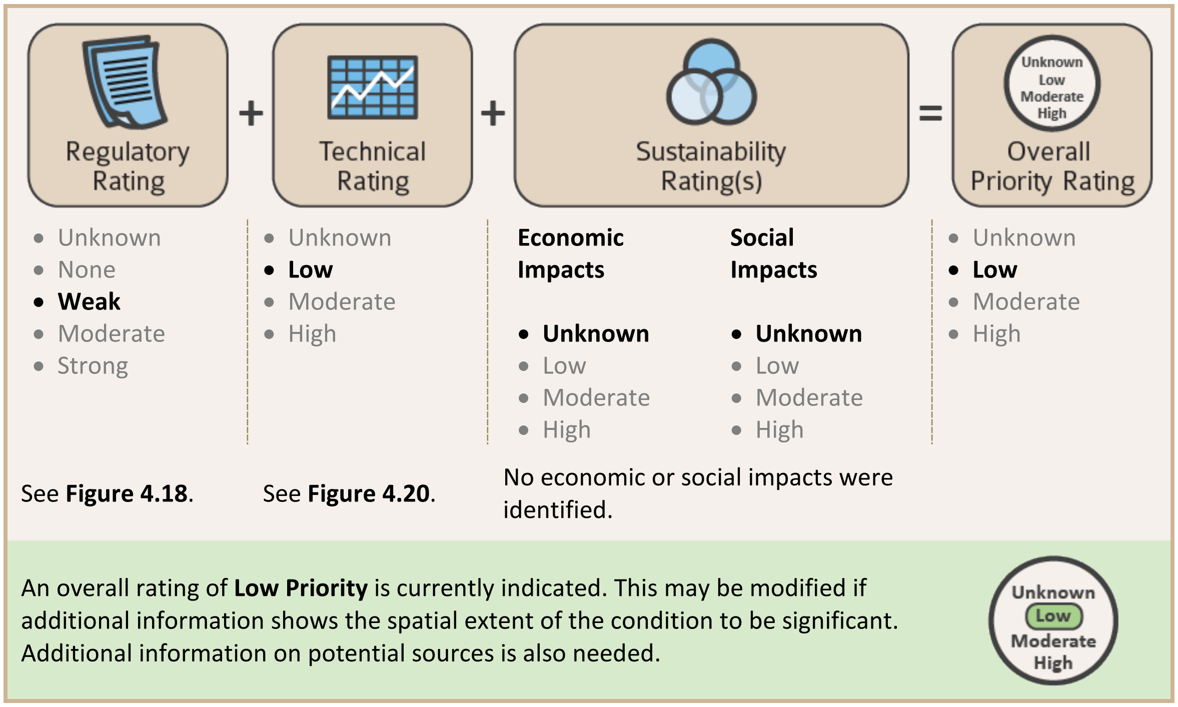


Figure 4.22: Establishing an Overall Priority Rating for a MS4 Problem – Copper Example

Table 4.10: Examples[4] of the Assignment of Overall Priority Ratings to MS4 Problem Conditions

Problem Condition	Tier 1: Regulatory Screening	Tier 2: Technical Rating				Tier 3: Sustainability Ratings			Overall Priority Rating
		Significance	*Certainty*	*Controllability*	*Overall*	*Economic Factors*	*Social Factors*	*Overall*	
Chemistry- Water Quality Problems									
Turbidity above Wet Weather Action Level at Outfall	**Strong**	Moderate	Moderate	Moderate	**Moderate**	Moderate	Low	Low-Mod	**High-Mod**
Nutrients exceed Water Quality Objectives in some portions of MS4	**Moderate**	Moderate	High	Moderate	**Moderate**	Moderate	Moderate	Moderate	**Moderate**
Copper above WQOs at 3 of 11 MS4 Outfalls	**Weak**	Low	Moderate	Low	**Low**	Unknown	Unknown	Unknown	**Low**
Toxicity Problems									
Limited wet weather data indicate Bifenthrin above the LC50 at MS4 outfalls	**Unknown**	Moderate	Low	Low	**Low-Mod**	Low	Low	Low	**Low**
Physical Problems									
High flow volumes and erosion within MS4; hydromodification in creek	**Unknown**	Low	Moderate	Moderate	**Moderate**	Moderate	Moderate	Moderate	**Moderate**

[4] These examples are hypothetical and for illustration only. They are not intended to imply a particular priority for any of the MS4 conditions listed.

Question 2 What is the relative importance of each MS4 problem?

For individual ratings of MS4 problem conditions to be useful in supporting decision-making, they must be evaluated together to determine their relative importance. As described, a variety of potential MS4 priorities are likely to be generated. Two types of scenarios should be considered. In the first, multiple MS4 segments or outfalls are compared to each other (e.g., the nitrate loadings of five outfalls to a receiving water). In the second, multiple priority problem conditions are compared at a single outfall or within a single MS4 segment. Both types of scenarios are important, and the approaches described here can be applied to either.

The final output of **Task 3** will be a ranked list of priority problem conditions for each MS4 or segment. Identified problems can either be put into a ranked order or be grouped by their priority ratings. Establishing ranked orders consists of lining up the applicable problem conditions for each receiving water or segment from highest priority to lowest, with the higher priorities normally constituting the greater management priorities. As illustrated in **Figure 4.23**, MS4 problems will sometimes have "tie scores." Rather than further differentiating between them, grouped rankings may be appropriate. Depending on the degree of information available, "sub-rankings might also be developed within each group.

	RANKED ORDER EXAMPLE	GROUPED RANKING EXAMPLE
↑ Increasing Priority ↑	1. Turbidity above wet weather action level 2. Nutrients above dry weather action level 3. High flow volumes and evidence of erosion 4. Copper above wet weather action level 5. Bifenthrin toxicity	**GROUP A (High-Mod)** • Turbidity above wet weather action level **GROUP A (Moderate)** • Nutrients above dry weather action level • High flow volumes and evidence of erosion **GROUP C (Low)** • Copper above wet weather action level • Bifenthrin toxicity

Figure 4.23: Potential Options for Ranking MS4 Problem Conditions

It's again important to emphasize the qualitative nature of this exercise. Its purpose is to establish an informational basis for comparing different types of MS4 problem. Rating and ranking systems cannot replace the role of judgment in evaluating results.

Managers must next decide which conditions will be targeted for change in **Step 5-B**. **Figure 4.24** below provides a Review Checklist to help guide the prioritization process. As in previous steps, significant data and information gaps are likely to be encountered along the way. It's critical to document these deficiencies and consider them in the development of future data collection strategies.

Review Checklist

Step 5-A Task 3
Prioritizing MS4 Problems

Apply this task individually to all problem conditions identified in Task 2. Its purpose is to assess and rank the priorities of problem conditions.

✓ For each identified problem condition, consider the following questions:

Question 1: What is the priority rating of each receiving water problem?

☐ **Tier 1: Regulatory Screening** **REGULATORY RATING ________**

- ✓ Identify regulatory requirements and constraints affecting priority.
- ✓ Based on their collective impact, assign a Tier 1 rating.
- ✓ Note the overall direction of influence of the rating (requirement or constraint).
- ✓ Should an Overall Priority Rating be assigned based solely on regulatory criteria? If yes, stop and document. If no, continue to Tier 2 Review.

☐ **Tier 2: Technical Review** **TECHNICAL RATING ________**

- ✓ Evaluate the significance, certainty, and controllability of the problem. Establish individual weightings as appropriate for each of the three factors.
- ✓ Based on review of the above factors, assign a Tier 2 Rating.
- ✓ Should the problem be eliminated from further consideration or assigned a "low" Overall Priority Rating based solely on technical criteria? If yes, stop and document. If no, continue to Tier 3 Review.

☐ **Tier 3: Sustainability Review** **SUSTAINABILITY RATING(S) ________**

- ✓ Identify economic factors and social factors affecting priority.
- ✓ Assign a Tier 3 Rating (or Ratings) for economic and social factors combined, or for each individually.

☐ **Overall Priority Rating** **OVERALL PRIORITY RATING ________**

Assign an Overall Priority Rating for each problem. Assign individual weightings to each factor as appropriate. Economic and Social factors may be counted individually or together.

Question 2: What is the relative importance of each MS4 problem?

☐ **Rank individual priority ratings for further consideration in Step B.**

✓ Document the critical data and information gaps identified during Task 3 completion.

NOTES

____

____

Figure 4.24: Review Checklist for Prioritizing MS4 Problems

Step 5 - B Targeted Changes to Urban Runoff and MS4 Contributions

Step 5-B addresses the establishment of measurable targets for changes in MS4 conditions. In addition to directing programs toward the resolution of problem conditions, targeting provides a context for establishing measurability, interpreting results, and evaluating success over time. Targeted changes should be considered wherever feasible, but at least for the highest priority MS4 conditions identified. As shown in **Figure 4.25**, targeting consists of three tasks.

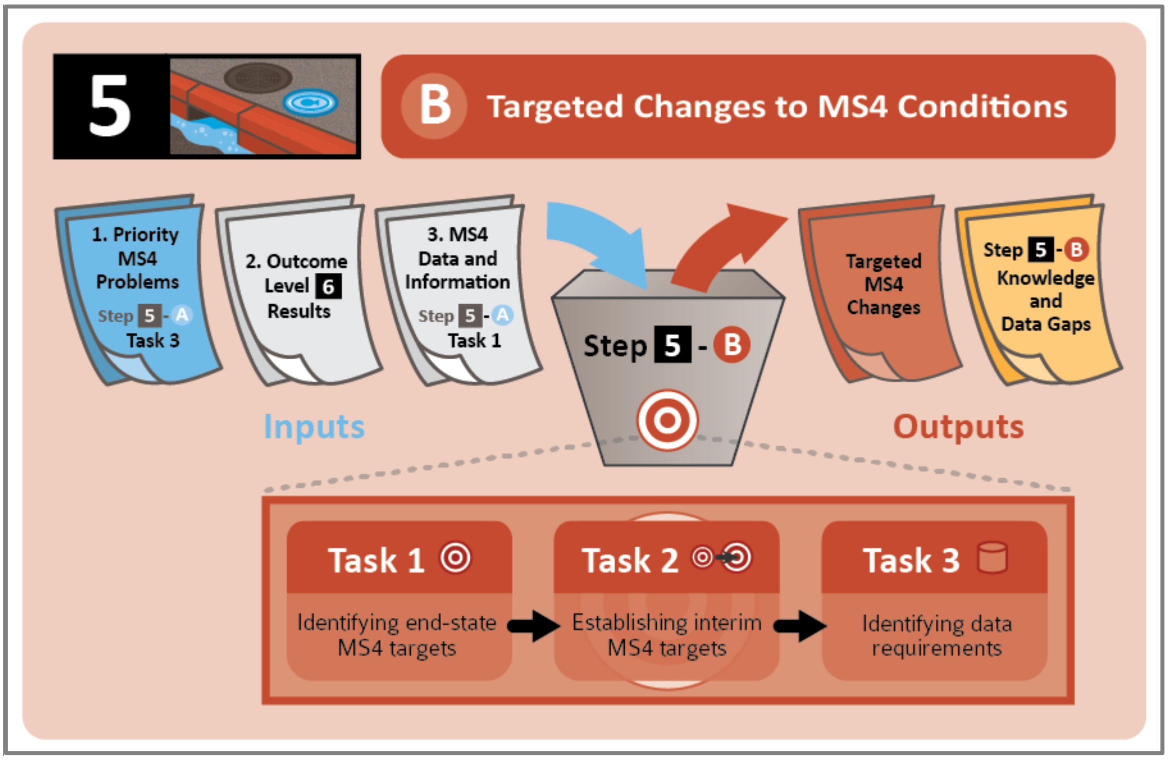


Figure 4.25: Targeting Changes to MS4 Conditions (Step 5-B)

Several types of inputs should be considered, starting with the list of **Priority MS4 Problems** identified in **Step 5-A Task 3**. For each identified priority MS4 problem, one or more specific targets for change should be considered. **Outcome Level 6 Results**, in particular, priority receiving water constituents, flows, and stressors, should also be reviewed for their applicability to MS4 priorities. Finally, managers should review all applicable **MS4 Data and Information** gathered in **Step 5-A Task 1**. Conditions that are common to receiving waters and MS4s (i.e., those for which there is a possibility of establishing causal linkages) are likely to emerge as higher priorities, so it's important that they be identified up front.

Task 1 Identifying end-state MS4 targets

This task focuses on defining the changes to be sought in identified priority problem conditions. It is guided by two general questions.

Step 3-B Task 1 Key Questions
Identifying End-state MS4 Targets

Inputs	Key Questions	Outputs
Priority MS4 Problems	**Question 1**: What is the end-state for the MS4 condition? **Question 2**: When will the end-state condition be achieved?	**End-state MS4 Targets**

Question 1 What is the end-state for the MS4 condition?

End-state MS4 conditions represent the absence of problems, or their reduction to acceptable levels. When targeting MS4 conditions, considerations of scale will be important. As already noted, MS4s normally exist in a many-to-one relationship with receiving waters. For example, consider a single receiving water segment for which ten contributing MS4 outfalls have been identified. Managers may determine that targeted outcomes should be developed for each outfall, or alternatively that targeting should apply to some or all of them as a group.

The establishment of targets should consider the review factors and general conceptual approaches described below.

Review Factors

As shown in **Figure 4.26**, several factors are applicable to establishing MS4 targets. These are the same general factors introduced above during problem prioritization.

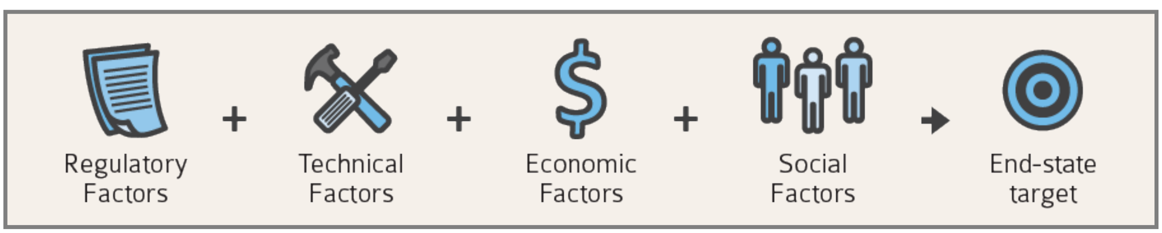


Figure 4.26: Factors Relevant to Setting Targets for MS4 Changes

Draft targets can initially be established through a consideration of regulatory and technical factors introduced above in **Task 5-A-3**, and those results further reviewed and refined as necessary in the context of sustainability considerations. This process may need to be repeated multiple times as additional data and information become available.

General Approaches to Establishing End-state MS4 Targets

Approaches to targeting may include any of the following, individually or in combination.

Setting Targets to Comply with Regulatory Requirements

Regulatory requirements should always be considered when setting MS4 targets. Since permits and other regulatory directives often leave little room for interpretation, compliance with them must be maintained. MS4 conditions that exceed defined regulatory criteria, or that can be directly linked to 303(d) listings or adopted Total Maximum Daily Loads, will typically be treated as higher priorities.

As discussed above for receiving water targets, end-state MS4 targets won't always be easily achievable within required timeframes. Where there is discretion to do so, it can make sense to set extended timeframes for achieving them. This allows managers to pursue interim targets that foster learning and adaptation along the way (see also approach #4 below).

Setting Targets to Achieve Receiving Water Improvements

This approach applies most directly to discharges from MS4s, but can also include changes that improve discharge quality or that reduce flow velocities within the MS4. The end-state for any MS4 problem will ideally be a condition that supports targets established for receiving waters. Where linkages between the two types of conditions are well-understood, it makes sense to target changes accordingly. This may be manifested as achievement of load reductions at MS4 outfalls or of specific conditions within the MS4 itself. Given their many-to-one relationship to receiving water impacts, this doesn’t necessarily mean the elimination of all MS4 contributions. It’s likely that changes in multiple MS4 contributions to any given receiving water will be targeted concurrently. The critical consideration in achieving receiving water improvements is the cumulative impact of reductions in MS4 contributions that are actually achieved. Some targets will most likely not be achieved and others may be exceeded. It’s therefore less important that each individual target be achieved than it is that they collectively not cause receiving water problems. Managers should also be realistic about the attainability of targeted conditions, and of the timeframes needed to achieve and measure them.

Setting Targets to Resource Availability

Stormwater programs are normally not be resourced to achieve all identified MS4 changes, so decisions must be made about how much and how quickly specific changes can be achieved. Every target must be established within the context of overall resource availability. Within these constraints, resource commitments will generally be greatest for those MS4 segments thought to represent the most significant contributions (e.g., pollutant loads or flows) to receiving water impacts. As above, it's important to emphasize that targets based solely on resource availability may fail to meet explicit regulatory requirements, or to satisfy the expectations of regulators or third parties.

Setting Targets to Learn and Adapt

This approach involves establishing targets to explore the potential for reducing MS4 contributions. Because MS4 conditions are sequentially linked both to level 6 and 4 conditions, managers can benefit from exploring relationships to both types of outcomes. **Experimental targets** support adaptive management approaches by exploring and testing assumptions or hypotheses about these relationships. As previously emphasized, planning is often hampered by the availability or sufficiency of data and information. Given that the types and amounts of changes in MS4 conditions that can be achieved will more often than not be unknown, it may sometimes make sense to explore potential changes experimentally. For example, if managers have a good idea of the types and levels of activities that can be directed to reducing loadings of a particular pollutant in a watershed area, they might establish a working hypothesis about the potential reductions at outfall levels. Pursuing changes in an "experimental" setting fosters increases in measurability that might eventually lead to the identification of causal linkages between observed changes.

One specific variation on this approach is through the establishment of **stretch targets**. Building on existing accomplishments can provide a reference point for "stretching" to see what can be done cost-effectively or within available resource commitments (note the similarity to approach #3 above). For example, existence frequencies of MS4 inspections or cleaning could be increased by a defined amount and results tracked to see if a relationship to improvements in specific MS4 or receiving water conditions (e.g., levels of trash) can be established.

Interim targets are also critical to the learning process because they provide opportunities for obtaining feedback along the way toward end-state conditions. These are discussed further under **Task 2**.

Table 4.11 illustrates a variety of examples of potential end-state MS4 targets for priority problems previously identified in **Table 4.10**. As described for receiving waters, the uncertainty associated with MS4 targeting is significant. The resolution of identified knowledge and data gaps should also be a priority for MS4 conditions.

Table 4.11: Examples[5] of End-state MS4 Targets

Problem Condition	Priority (from Table 4.11)	End-State Target	Explanation
Turbidity above Wet Weather Action Level at Outfall	High-Mod	Reduce TSS concentrations by 20%	20% reduction is targeted in combination with other programmatic stretch targets.
Nutrients exceed Water Quality Objectives in some portions of MS4	Moderate	Decrease levels to below WQOs at 50% of stations	Exceedance of WQOs within the MS4 is not a permit violation. Some flexibility exists in targeting so long as persistent exceedances are not occurring at outfalls.
Copper above WQOs at 3 of 11 MS4 Outfalls	Low	Maintain current conditions, or pursue measurable reductions through continued implementation	Exceedances are only at about one-quarter of outfalls, and there is no evidence of receiving water impacts. This is a low priority for change. Reductions might also be approached experimentally.
Limited wet weather data indicate Bifenthrin above the LC50 at MS4 outfalls	Low	Reduce Bifenthrin toxicity to below LC50 at 75% of outfalls	Reduction is not a strict regulatory requirement, so it doesn't need to apply to all outfalls. This might be approached as a stretch target and monitored over time.
Evidence of high flow volumes and erosion within MS4; corresponds to hydromodification in creek	Moderate	Reduce peak flows and volumes	Target lacks a specific measurable endpoint. It might be initially approached experimentally with a goal of "filling in the gaps" through trial-and-error or ongoing evaluation of resource availability.

[5] These examples are hypothetical and for illustration only. They are not intended to imply a particular target or timeline for any of the MS4 conditions listed.

Question 2 When will the end-state condition be achieved?

Whenever possible, a targeted MS4 change should specify the timeframe in which it is expected to be achieved. Without this, it's impossible to assess whether or not a program is making reasonable progress toward it. Where targets are already established by permit or TMDL requirements, these timelines may already be known. However, where there is discretion, managers should instead consider the time needed to realistically achieve the change. While changes in MS4 conditions can often be achieved on shorter timeframes than those in receiving waters (see **Figure 3.16**), they can still take decades or longer to achieve. Exceptions include conditions under the direct influence of the stormwater program, e.g., those related to MS4 maintenance or the construction and operation of structural controls. As discussed above for receiving waters, allowances must also be made for the time it takes to "ramp up," refine, and fully implement the programs expected to drive changes.

Due to the inherent variability of many MS4 conditions, their measurement should also reflect the timeframes needed to measure them with a reasonable degree of statistical certainty. As described in **Key Concept 4.2**, the ability to statistically detect change normally increases as a function of time.

Task 2 Establishing interim MS4 targets

Since end-state MS4 targets can often take years or decades to achieve, it's important to set a course of action that includes incremental measures of progress. The establishment of interim targets is guided by two questions.

Step 3-B Task 2 Key Questions

Establishing Interim MS4 Targets

Inputs	Key Questions	Outputs
End-state MS4 Targets	**Question 1**: What interim targets are needed to evaluate progress toward the end-state MS4 condition? **Question 2**: When will interim MS4 targets be achieved?	**Interim MS4 Targets**

Question 1 What interim targets are needed to evaluate progress toward the end-state MS4 condition?

Interim MS4 targets allow for the assessment of incremental progress toward end-state conditions, and provide feedback necessary for refining management approaches along the way. Approaches to targeting MS4 changes will generally be similar to those already discussed for receiving waters. Where possible, interim targets should reflect critical events in the implementation curve (e.g., the time it takes to "ramp up," refine, and fully implement the programs expected to drive changes).

For MS4s that discharge to water bodies under a TMDL, interim targets may be defined in the TMDL schedule for waste load reductions. Some may also be defined in MS4 permits for a given permit cycle or defind in permit-required watershed management plans. Interim targets for dry weather flows can usually be more aggressive than wet weather flows, but are still constrained by limits on the understanding of and ability to address contributing sources. Spatial considerations and resource availability can also be important in setting interim targets. For example, load reductions might be focused on the highest loading outfalls or a select set of outfalls that drain to a specific impacted segment of a receiving water. Doing so might allow a greater degree of experimentation and for more sampling resources to be dedicated to their assessment.

Question 2 When will interim targets be achieved?

Where timelines for achieving interim targets for MS4 change are not already be defined in TMDLs, NPDES permits, or permit-required plans, their establishment should reflect the same practical considerations noted above (the time needed to ramp up control measures, to realistically achieve and measure specific changes, etc.). The variability of water quality and other environmental data can be even more constraining for interim targets because of the challenges associated with statistically defining change on comparatively shorter timeframes. In most cases it will not be possible to assess attainment of changes over short intervals (e.g., 1-2 years) with reasonable confidence. Measurement of changes within MS4s (e.g., reductions in pollutant loadings or concentrations) should generally be based on data collected over periods greater than five years or greater. As noted, however, shorter timeframes may be appropriate for conditions under the direct influence of the stormwater program.

Task 3 Identifying data requirements

Now that targets for MS4 change have been identified, it's necessary to identify how they will be measured, what data are needed to allow measurement, and how these data will be collected and analyzed. Planning is not complete unless managers are fully prepared to obtain and evaluate the data needed to assess each targeted change. Each of the questions below should be addressed for every targeted outcome addressed in **Step 5-B**.

Question 1 What metrics will be used?

End-state and interim urban runoff and MS4 conditions should both be expressed in unambiguous terms. This should include a specific formulation of the outcome statement, the assignment of units of measure or assessment, and units of time. **Section 7.3** provides additional detail on the establishment of metrics.

Question 2 What data collection methods will be used?

It's also essential that managers identify how data will be collected for each targeted MS4 outcome so that it can be tracked and assessed. **Section 7.4** provides additional detail on potential data collections options.

Question 3 What data analysis methods will be used?

The last consideration for any targeted urban runoff and MS4 outcome is how the data will be evaluated. The choice of analytical method can dictate what specific metrics should be used, how the data should be collected, and the quality of the result. **Section 7.5** provides additional discussion of data analysis options. Where the establishment of MS4 data requirements cannot be satisfactorily addressed up front (e.g., there's no available option for collecting the desired data), this may need to be documented as a knowledge and data gap (**Step 6-C**).

Figure 4.27 provides a Review Checklist to guide **Step 5-B** completion.

Review Checklist

Step 5-B Tasks 1, 2, and 3

Targeted MS4 Changes

Apply this task individually to all MS4 conditions selected for targeting in Step A Task C (Prioritizing MS4 Conditions). Its purpose is to identify specific targets for change in problem conditions.

✓ **End-state Targets (Task 1)**
Consider the following questions:

Question 1: What is the end-state for the problem condition?
Question 2: When should the end-state condition be achieved?

✓ **Interim Targets (Task 2)**
Consider the following questions:

Question 1: What interim targets are needed to evaluate progress toward the end-state condition?
Question 2: When will interim targets be achieved?

✓ **Data Requirements (Task 3)**
Consider the following questions:

Question 1: What metrics will be used?
Question 2: What data collection methods will be used?
Question 3: What data analysis methods will be used?

✓ **For each priority MS4 problem, document interim and end-state targets, and the data requirements necessary to track and evaluate them.**

✓ **Compile one or more lists of targeted MS4 changes and supporting documentation for listed conditions.**

✓ **If a priority MS4 change is not or cannot be targeted, document the reason.**

✓ **Document all Step B data and information gaps.**

NOTES

Figure 4.27: Step 5-B Tasks 1, 2, and 3 Review Checklist

Step 5 - C Documenting Knowledge and Data Gaps

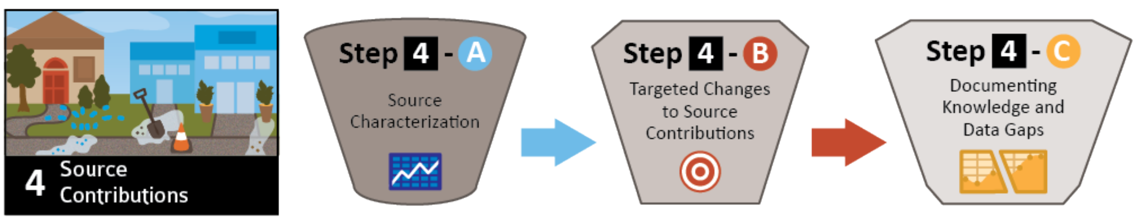
As previously described, the identification of knowledge and data gaps should be ongoing throughout the entire Level 5 planning process. At its conclusion, managers should have developed a list of gaps that can be incorporated into an assessment strategy. **Section 7.0** provides additional guidance on assessment tools and strategies to support the development of these strategies. Because an existing baseline of data and information does not exist for many urban runoff and MS4 conditions, Level 5 knowledge and data gaps can be significant. Critical gaps must be addressed to ensure that they are resolved over time. **Table 4.12** provides examples of general areas of inquiry where Level 5 knowledge and data gaps are likely to be encountered. These are intended to provide a framework for identifying actual knowledge and data gaps, which will be much more specific than those listed here.

Table 4.12: Potential Areas of MS4 Knowledge and Data Gaps

- ✓ Understanding of MS4 conditions (nature, magnitude, variability, and trends)
- ✓ Adequacy of sampling data (sample size, representative sampling, etc.)
- ✓ Adequacy of action levels or other regulatory criteria
- ✓ Knowledge of regulatory requirements and constraints affecting MS4s
- ✓ Knowledge of economic factors affecting MS4s
- ✓ Knowledge of social factors affecting MS4s
- ✓ Methodologies, criteria, and data support for conducting problem identification
- ✓ Methodologies, criteria, and data support for prioritization

4.4 Outcome Level 4: Source Contributions

Level 4 Outcomes deal with sources of pollutants and flow to MS4s and receiving waters. A **source** is anything with the potential to generate urban runoff flow or pollutants prior to their introduction to the MS4. Most stormwater programs address a variety of sources corresponding to the major sectors of existing and new development. Sources are the final component of the physical system described in this section. Pollutants and flows generated by sources are transported via MS4s (Level 5) to receiving waters (Level 6) where they can cause or contribute to a number of potential problem conditions. Level 4 planning addresses their identification and characterization as a basis for the further development of control strategies in Section 5.0 (Target Audience Strategies) and Section 6.0 (Program Implementation Strategies). It is a three-part process.



In **Step 4-A** managers review existing data and information to evaluate drainage areas, individual sources, or source categories. Initial results are then narrowed to focus on priority problem conditions. **Step 4-B** focuses on defining the changes that will be sought in within priority drainage areas over time. Finally, **Step 4-C** identifies the knowledge and data gaps discovered along the way, so that future data collection initiatives can be directed toward resolving them.

As shown in **Figure 4.28**, source characterization consists of three tasks. It begins with a review of available data and information for contributing drainage areas and sources. Drainage areas are considered first because they define the potential scope of applicable source contributions. With the exception of “preventive” and “experimental” program initiatives (see **Task 1, Question 1** and **Step 4-B, Task 1** below) the direction of resources to sources that do not have a physical connection or an otherwise reasonable linkage to priority MS4s or receiving waters should be avoided.

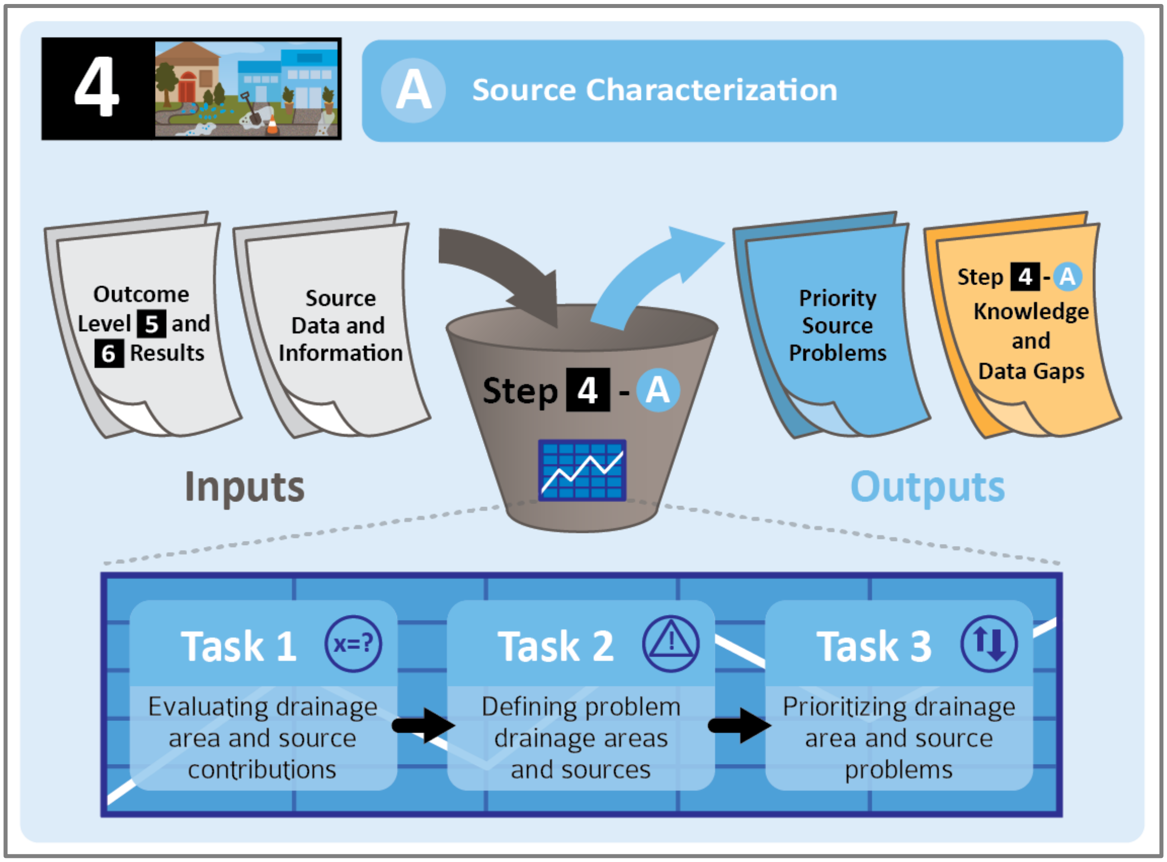


Figure 4.28: Source Characterization (Step 4-A)

Table 4.13 identifies a variety of data and information resources that can be used to inform Level 4 strategic planning. A good starting point is to review data collected by the MS4 program itself, most typically previously-conducted receiving water and MS4 monitoring. Likewise, a variety of external sources such as regulatory agencies, research institutions, and published research, may be useful in augmenting locally-collected data. While a number of sources exist for drainage areas and a variety of source types, detailed data and information can often be lacking. For example, while inventories and locations of commercial and industrial sources can often be compiled relatively straightforwardly (e.g., through business license databases), detailed data on specific attributes associated with facilities (PGAs and pollutants, discharge potential, etc.) can be difficult to obtain. Ultimately the development of effective control strategies for many sources may require a level of knowledge that does not yet exist. The identification and resolution of critical knowledge and data gaps is therefore an important consideration for Level 4 planning (see **Step 4-C**).

Table 4.13: Potential Sources of Drainage Area & Source Data and Information

Outcome Level 5 & 6 Results (From Sections 4.2 and 4.3)
☑ Receiving Water and MS4 Characteristics (pollutant loadings, hydrology, beneficial use designations, CWA Section 303(d) listings, TMDLs, etc.)
☑ Priority Receiving Water and MS4 Problems (priority constituents and stressors, impacted sites, segments, or locations, etc.)
☑ Targeted Receiving Water and MS4 Changes
☑ Outcome Level 5 and 6 Knowledge and Data Gaps
Drainage Area Data and Information
☑ Drainage area maps (hard copy, GIS, etc.)
☑ Regulatory and planning agency data, maps, and reports (land use, hydrology, etc.)
☑ Online repositories, directories, and databases (CERES, SWAMP, etc.)
☑ Published or unpublished research, literature, and technical reports
☑ TMDLs (source delineation, pollutant loading estimates, etc.)
Source Data and Information
☑ Existing source inventories (commercial, industrial, construction, etc.)
☑ Facility or site inspections, monitoring, development plans, etc.
☑ Regulatory and planning agency data, maps, and reports (population, demographics, etc.)
☑ Published or unpublished research, literature, and technical reports
☑ Tax assessor databases
☑ Commercially available sources of business data (Standard and Poor, online or CD business directories, etc.)
☑ Published research, literature, and technical reports
☑ Special studies and investigations

Task 1 Evaluating Drainage Area and Source Contributions

Building on the results of Level 5 planning, managers will evaluate identified data and information relating to drainage areas and sources contributing discharges to MS4s and receiving waters. At this point all potential conditions should be of interest. Evaluations are guided by four key questions.

Step 4-A Task 1 Key Questions

Evaluating Drainage Area and Source Contributions

Inputs	Key Questions	Outputs
Available Data, Information, and Results	**Question 1:** Which drainage areas contribute pollutants and flows to MS4s? **Question 2:** Which sources contribute pollutants and flows to the MS4? **Question 3:** What are the current flow and pollutant contributions of drainage areas and sources? **Question 4:** How are drainage area and source contributions changing over time?	**Drainage Area and Source Contributions & Characteristics**

Question 1 Which drainage areas contribute pollutants and flows to the MS4?

This question focuses on the physical connectivity between priority MS4s (**Step 5-A, Task 3** above) and the sources that contribute pollutants or flows to them. A critical concept in the identification of sources is the drainage area. A **drainage area** is any geographic area (watershed, watershed-jurisdiction, basin, sub-basin, etc.) that contains sources of pollutants or flow. Drainage areas are distinct from **drainage basins**, which are defined solely by patterns of runoff or flow. Drainage areas are different in that they represent decisions made during program planning about how assemblages of potential source contributions will be defined. A drainage area can contain multiple drainage basins, and vice versa. The alignment of drainage areas and drainage basins can be extremely important to gaining a proper understanding of pollutant and flow contributions.

Figure 4.29 illustrates drainage areas mapped at a variety of different scales (jurisdiction, watershed, sub-watershed, drainage management area, neighborhood, etc.). As shown, there are numerous potential options for defining drainage areas. Depending on specific objectives, many of these can also be explored in combination. Regardless of scale, the critical issue in all cases is understanding the connectivity of the selected drainage area to the MS4 or specific MS4 segments, and indirectly to receiving waters.

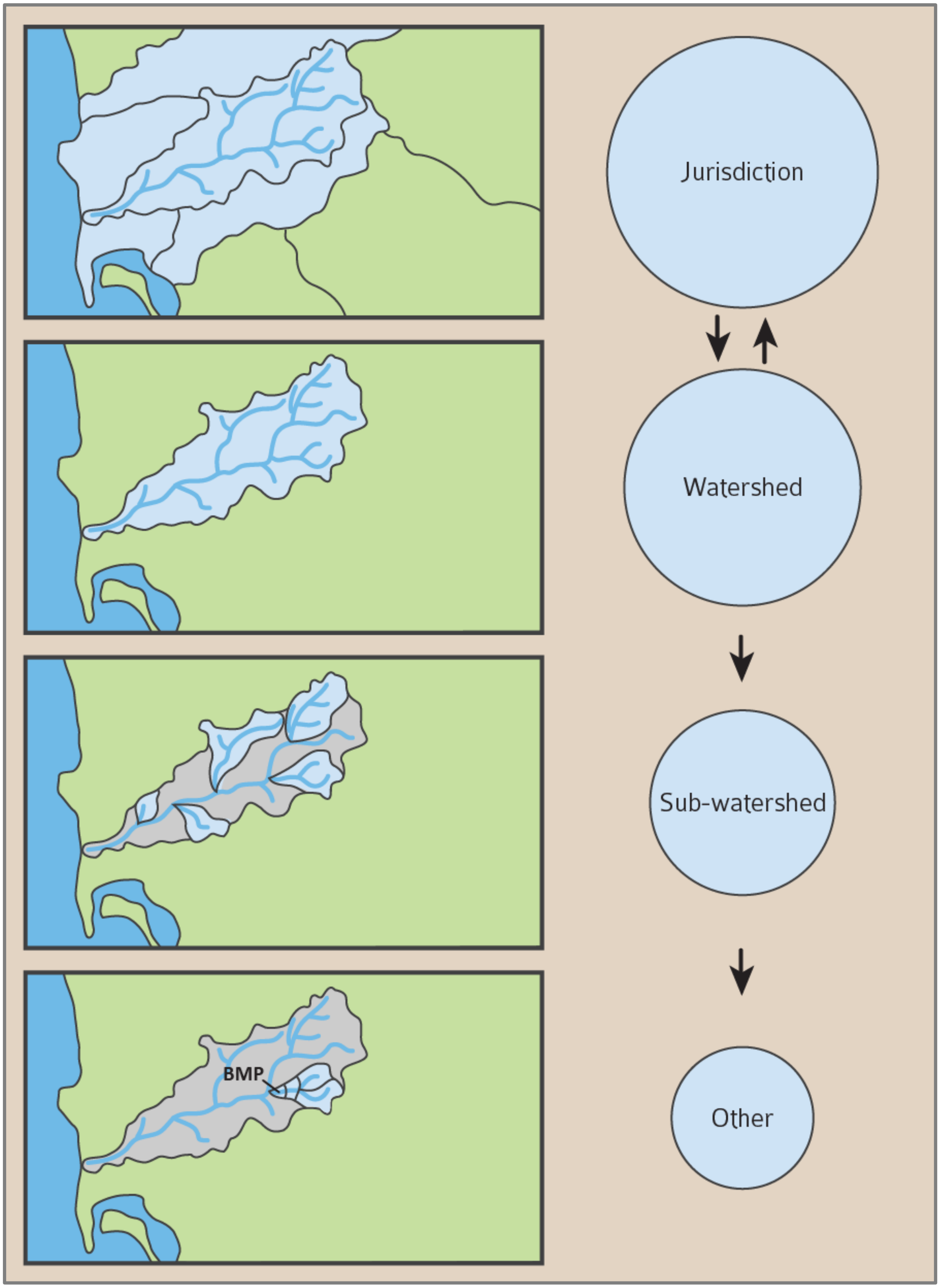


Figure 4.29: Drainage Areas at Various Scales[6]

[6] In this example, jurisdictions and watersheds are interchangeable since either can contain the other.

Normally managers will be most interested in drainage areas that discharge to priority receiving waters through MS4s. In a very broad sense drainage areas can be, and often are, treated as sources since they represent the collective loadings of all the individual sources they contain. Drainage areas also define opportunities for other interventions such as the construction of structural treatment controls.

Failure to adequately define drainage areas can result in the misdirection of control strategies toward sources that are not actually contributing to priority receiving water problems. Scale is a critical consideration. In general, the finer the scale (e.g., a sub-watershed or smaller drainage area rather than an entire jurisdiction or watershed), the more likely that control strategies can be directed with greater precision. A broadly based program element that assumes a physical connection between all priority sources and receiving water impacts within the drainage area can actually result in a “mismatch” of problem conditions and potential solutions. It’s critical that sources and impacts be aligned with as much specificity as possible so that the correct contributing sources can be targeted for each priority impact.

While the most critical consideration in defining a drainage area is initially its boundaries, each individual area will also have a number of other attributes that should be considered during characterization. These will later be important in the development of control strategies. Examples of attribute types are provided in **Table 4.14**. Once applicable drainage areas have been identified and characterized, the focus of planning will shift to the sources of pollutants and flows contained within them. However, as shown, sources (residential areas, commercial inventories, etc.) are also an important consideration for defining drainage areas. In this sense, planning does not always follow a linear process. Contributing sources will need to be identified provisionally during the definition of drainage areas, and later evaluated in greater detail during source prioritization and targeting.

Table 4.14: Examples of Drainage Area Attributes

Land Area Characteristics

☑ Geographic boundaries

☑ Land uses (residential, industrial, transportation, etc.)

☑ Zoning classifications (residential, commercial, mixed use, etc.)

Sources of Pollutants and Flow

☑ Areas of pollutant and flow generation (area-wide, land use-specific, etc.)

☑ Source locations (industrial areas, facility locations, etc.)

Population Characteristics

☑ Demographics (ethnicity, gender, age, etc.)

☑ Population distribution (density, communities, etc.)

Physical Characteristics

☑ Locations of receiving waters and MS4s

☑ Patterns of precipitation and runoff

☑ Topography, soil types, and vegetation

☑ Areas of imperviousness, open space, or infiltration

Question 2 Which sources contribute pollutants and flows to the MS4?

A **source** is anything with the potential to generate urban runoff flow or pollutants prior to their introduction to the MS4. Most stormwater programs address a variety of sources corresponding to the major sectors of existing and new development. The identification and characterization of sources is a critical part of the planning process because it largely defines how control strategies will be directed. It's therefore useful to consider the ways in which decisions about source content and priorities can be approached. There are two primary approaches to identifying potential sources.

- Source-based ("preventive") approaches, and
- Constituent-based ("corrective") approaches.

One begins with an understanding of problem conditions in receiving waters and MS4s, and the other with the sources themselves. Either can be useful depending on the situation, and managers should generally find both to be necessary. No program can be considered to be entirely source-based or constituent-based.

Source-based approaches focus first on sources and associated target audiences (Levels 2, 3, and 4) within a defined drainage area, often in the absence of a detailed knowledge of existing water quality impacts. They are normally designed to anticipate potential problems, and as such can be considered "preventive." Although the details vary, MS4 permits and programs are typically organized according to the broad source categories identified in **Table 4.15**[7]. To varying degrees, each of these categories will play some part in most stormwater management strategies.

The primary advantage of a source-based emphasis is its close alignment with existing regulatory and operational programs (business inspection programs, building permit programs, capital improvement programs, etc.), making the selection of sources, and the subsequent development and administration of many program activities, fairly straightforward. As such, source-based approaches often have a high return on investment.

Table 4.15: Major Source Categories and Examples of Specific Source Types

Existing Development			New and Redevelopment	
Municipal Sources	**Residential Sources**	**Industrial/ Commercial Sources**	**Construction Sources**	**Development & Redevelopment Sources**
• Solid waste facilities • Wastewater operations • Streets and roads • MS4s • Parks • Office buildings	• Single family housing • Multiple family housing • Apartments • Mobile homes • Rural residential areas • Inner city neighborhoods	• Restaurants • Automotive maintenance • Nurseries • Horse stables • Mobile operations (landscaping, pool care, pest control, etc.)	• Commercial and industrial development • Single family homes • Major subdivisions • Capital improvement projects • Redevelopment sites	• Commercial and industrial development • Single family homes • Major subdivisions • Capital improvement projects • Redevelopment sites

While source categories are useful for organizational purposes, they are often too broad and inclusive for many detailed strategic planning tasks. In practice, each will usually require further subdivision into more specific source types (e.g., commercial sources into restaurants, automotive service establishments, etc., or residential sources into

[7] Note the close correspondence of these source categories to the CASQA BMP Manuals and the profiles presented in **Attachment A** of this manual).

apartments, rural residential, etc.) and target audiences (equipment operators, food service workers, dog walkers, etc.) to which particular management initiatives can be directed. **Figure 4.30** provides an example of a source-based organizational approach. In this example, note the position of priority constituents at the bottom of the figure. Because source-based approaches tend to focus first on the identification of sources and target audiences, and then the activities and practices associated with them, constituents or stressors tend to be considered much later in the planning process. This is a hypothetical example. Real world conditions are much more complex. A typical MS4 permit contains requirements to address all major source categories, each of course subdivided into numerous additional individual source types, target audiences, and activities and practices. Each identified activity or practice might also address multiple priority constituents.

As control strategies are later developed for priority constituents and sources, it will also be important to know as much as possible about each of them. Managers should therefore always be interested in characterizing the relevant attributes of each priority source. **Table 4.16** lists a number of general attributes that might be considered. The actual selection of attributes will depend on resource availability, and the nature and priority of the source. Often the priority of individual source types won't yet have been determined, so this aspect of characterization may need to be returned to later.

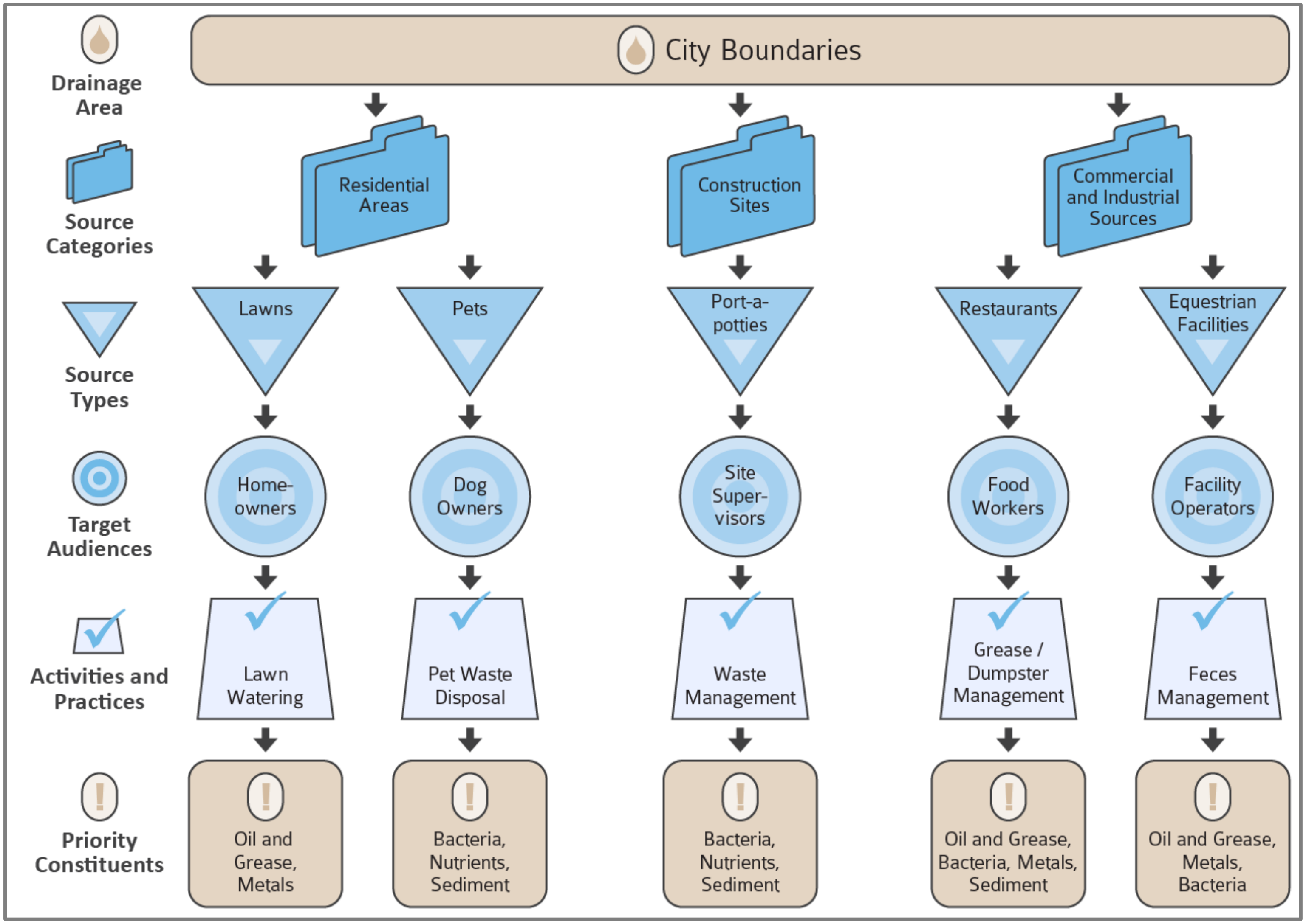


Figure 4.30 Simple example of a source-based (or "preventive") organizational approach

Table 4.16: Examples of Source Attributes

Site or Facility Information

- ☑ Number, size and types of sites or facilities (businesses, residences, etc.)
- ☑ Locations (proximity to receiving waters and MS4s, clustering, etc.)
- ☑ Onsite hydrologic conditions (incl. areas of imperviousness, open space, or infiltration)

Activities and Practices

- ☑ Operations conducted
- ☑ Materials and wastes
- ☑ PGAs and BMPs conducted
- ☑ Presence of structural BMPs

Target Audience Attributes

- ☑ Identification of target audiences (incl. primary and secondary, and segmentation as necessary)
- ☑ Job responsibilities
- ☑ Numbers and types of employees, contractors
- ☑ Levels and types of education or training
- ☑ Population distribution (density, communities, etc.)

Source Contributions

- ☑ Dry weather discharges of pollutants or flows (potential or actual)
- ☑ Wet weather discharges of pollutants or flows (potential or actual)

Constituent-based approaches are more typical of watershed management initiatives, particularly those associated with Total Maximum Daily Loads (TMDLs). Here the starting point is the establishment of the priority constituents associated with receiving water and MS4 impacts. Numerous constituents may be of interest. The list below currently represents the constituents that are most frequently 303(d)-listed in California. Detailed profiles of each are provided in **Attachment C**.

- Bacteria
- Sediment
- Nutrients
- Mercury
- Pesticides
- Trash

Constituent-based approaches are typically "corrective" in that they are designed to resolve documented receiving water or MS4 problems (Levels 5 and 6[8]) within a defined area. **Figure 4.31** provides an example of a constituent-based approach and illustrates how other organizational parameters can be accommodated within it. In this case, note the position of a priority constituent (bacteria) at the top of the figure.

Constituent-based approaches can be preferable if a good understanding of receiving waters or urban runoff conditions has been established – often the case where monitoring programs have been in place for long periods. The primary advantage of these approaches is their "problem-solving" orientation to priority water quality issues. By allowing the exclusion or de-emphasis of sources, target audiences, and pollutant-generating activities that do not contribute to these problems, resource commitments can often be reduced or redirected to those that do.

This does not mean that source-based approaches are inherently less efficient. Most managers have extensive experience managing their source inventories, and may often have a detailed understanding of their source priorities -- whether or not they're directed to resolving identified water quality problems.

Each approach follows a slightly different path, but both eventually bring managers to essentially the same place, i.e., the selection of stormwater program activities to bring about specific behavioral changes in priority target audiences. Which approach is better depends on the situation, and one is rarely chosen exclusively over the other. In most instances, programs will reflect a mix of source-based and constituent-based elements.

Question 3 What are the current flow and pollutant contributions of drainage areas and sources?

By far the most critical attributes of drainage areas and sources will be their flow and pollutant contributions to priority MS4s and receiving waters. Since the primary focus of most stormwater management programs is to facilitate reductions in these contributions, it's necessary to first understand what they are.

---

[8] This is a definitional distinction. It's possible that management approaches can be designed to "correct" source loadings without actual knowledge of the receiving water or MS4 impacts caused by them. However, an approach is considered "corrective" here when it is designed to respond to a known or suspected impact.

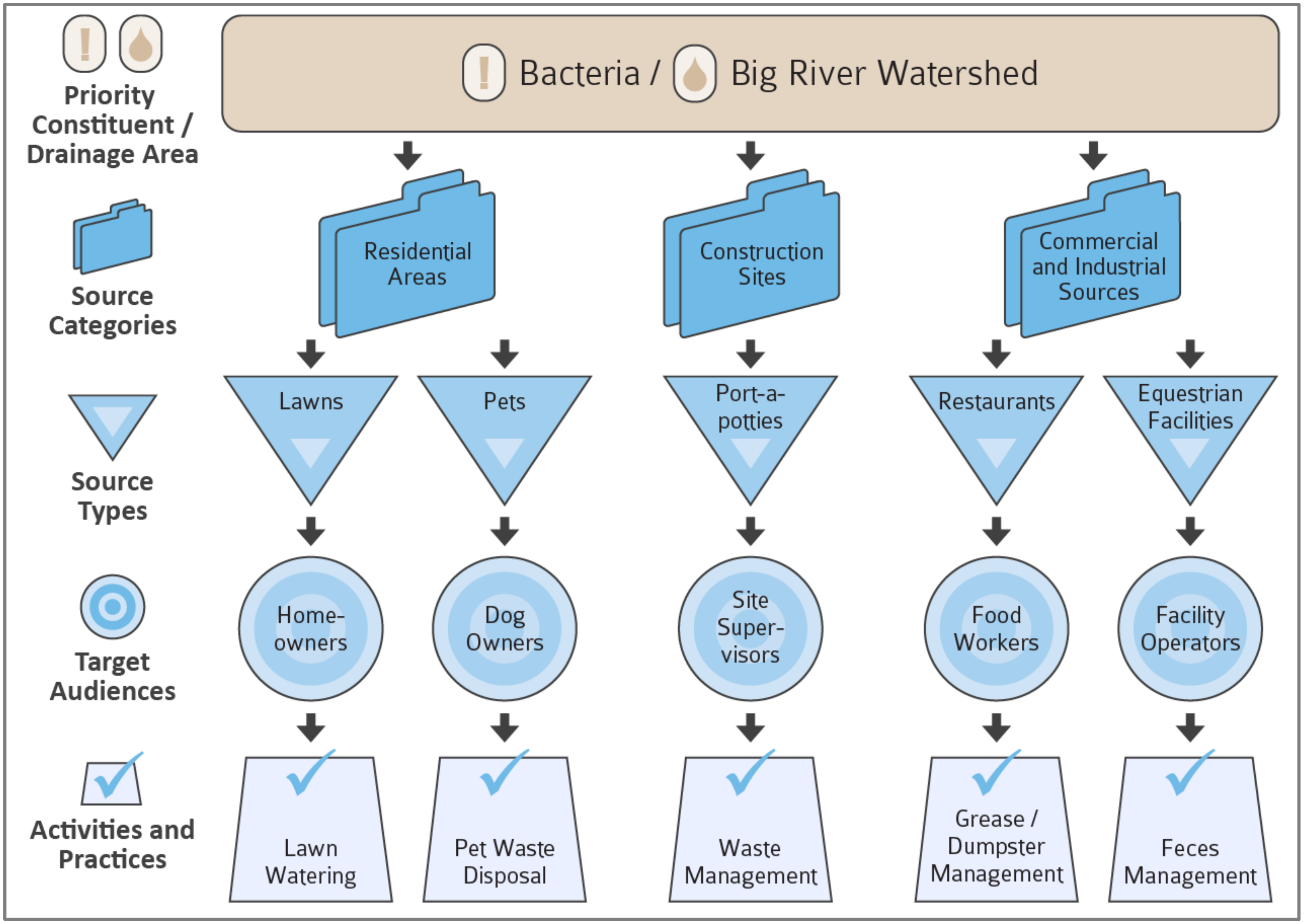


Figure 4.31 Simple example of a constituent-based (or "corrective") organizational approach

Source contributions can refer either to **source loadings** (flows and pollutant loadings added by sources to a MS4) or **source reductions** (reductions in flows or amounts of pollutants associated with specific sources before and after control measures are employed). Source reductions are the primary means by which stormwater programs are able to induce positive changes in receiving waters. In practice, it's often not possible to directly measure or observe a loading or reduction. Instead managers often rely on estimates of **source potential** (also typically expressed as **threat-to-water-quality**). Source potential describes the likelihood that a given source type will discharge flows or pollutants during wet or dry weather conditions. Managers must often rely on estimations of source potential to determine the magnitude or relative importance of a source contribution.

The discussion below applies to the characterization of both pollutant and flow contributions. It's also important to remember that drainage areas can sometimes be treated as sources, especially with regard to the estimation of source contributions from broad geographic areas (e.g., residential land uses). For example, TMDLs often contain pollutant waste load allocations for specific land uses. In this respect "drainage area contributions" are a form of "source contribution."

Nature and Magnitude

The **nature** of a source contribution refers primarily to its substance. **Substance** is the physical composition of the flow or pollutant loading being discharged from the source (i.e., what is being loaded or reduced?). As shown in **Table 4.17**, substance can be categorized in three ways.

- Materials and Wastes (street sweeping debris, used motor oil, etc.)
- Pollutants (copper, nitrates, bacteria, etc.)
- Flows (volume, rate, etc.)

The purpose of these categories is to facilitate characteriztion. They are not mutually exclusive. For example, a flow can contain pollutants or a pollutant could be one of multiple substances comprising a material (e.g., nitrates in fertilzer). The selection of one type of substance over another will be situation-specific. Also note that the examples of substances included in **Table 4.17** correspond very closely with conditions many of the previously described for receiving waters and MS4s. The primary difference is that only substances that can be discharged from a drainage area or source are included here.

Table 4.17: Examples of Drainage Area and Source Contribution Types

Type of Contribution	Examples
Materials and Wastes	• Fertilizers • Yard waste • Paint • Automotive fluids (motor oil, brake fluid, etc.) • Trash and debris
Pollutants	
Chemical Constituents	• Metals (e.g., Cd, Cu, Cr, Pb, Ni, Ag, Zn) • Pesticides (e.g., organophosphates, pyrethroids) • Nutrients (e.g., nitrates, phosphates)
Biological Constituents	• Bacterial indictors (total and fecal coliform, enterococcus, etc.) • Pathogens (bacteria, viruses, protozoa, etc.)
Physical Constituents	• Sediment • Floatables • Temperature
Flows	• Stormwater flows (volume, velocities, and durations) • Non-stormwater flows (presence or absence, volume, velocities, and durations)

Source contributions have traditionally concentrated on materials, wastes, or pollutants. However, recent trends in permitting have shifted some of that focus to the impacts of flows generated by specific source types or within drainage areas. This is because changes in stream hydrology (e.g., more frequent flooding, destabilized stream banks, or degradation of stream habitat) are often associated with the impervious surfaces that are created when urbanization takes place. As such, understanding and managing hydrologic conditions on or discharging from properties or sites is also now an important objective for many programs. To date, most of this emphasis has been on new development and redevelopment sites, but some MS4 permits are now requiring that flow conditions be addressed for areas of existing development.

In addition to its nature, it's necessary to understand the magnitude of each contribution. **Magnitude** describes dimension or scale. Depending on the type of condition, and the particular approach to its measurement, magnitude can be expressed in a number of different ways, e.g., the concentration or weight of a chemical constituent, the volume or weight of a material, or the peak velocity of a stormwater flow. Regardless of how it's expressed, magnitude provides an indication of the relative importance of a particular contribution, and therefore of its potential priority. The magnitude of each source loading will also have temporal and spatial aspects.

Temporal characteristics address the rate, duration, and timing of the source contribution. **Rate** is a quantification of the amount of a loading or reduction over a unit of time (e.g., 50 lbs./year), whereas **duration** defines the period over which it occurs (an hour, a year, a season, etc.). Along with nature and magnitude, rate and duration are necessary for the quantification of source contributions. Examples of both are provided in **Table 4.18**. The specific **timing** of source contributions (e.g., weekend versus weekday) is also very important to gaining a full understanding of the condition, as well as potential options for controls. However, timing isn't as critical for quantifying loadings.

Table 4.18: Examples of Temporal Characteristics of Source Contributions

Rate	Duration	Timing
• 4 gallons (e.g., an "instantaneous" event) • 10 ft^3 / min.(e.g., continuous discharge of process water) • 3-10 gal. / minute (intermittent or variable discharge)	• Instantaneous (e.g., littering or dumping oil in a drain) • Six hours, two weeks, three months, etc. • An annual reporting period (one year) • A rainfall event	• Evenings, weekends, business hours, etc. • Wet or dry season • Daily, weekly, monthly, etc. • Episodic (e.g., only during rainfall)

Spatial scale is also important for describing the magnitude of a source contribution. Scale defines where and how loads or reductions can be measured or calculated. As shown in **Figure 4.32**, four scales are of particular importance.

- **Individual practices** are PGAs and BMPs. Analysis of PGAs will typically be used for investigating source loadings and BMPs for reductions. This can also include structural controls such as infiltration basins and treatment control BMPs.
- **Sites** are discrete locations such as commercial facilities or residences. Depending on the specific scale, they can be treated as either point or area features.

- **Land areas** are geographically-based units. Land areas can only be represented as area features. Land area approaches are frequently used to develop waste load allocations for TMDLs.
- **Populations** are the groups of individuals associated with sources. The term "population" can sometimes be used inter-changeably with target audience. Populations normally represent heterogeneous distributions of individuals, so the variability within them is an important consideration.

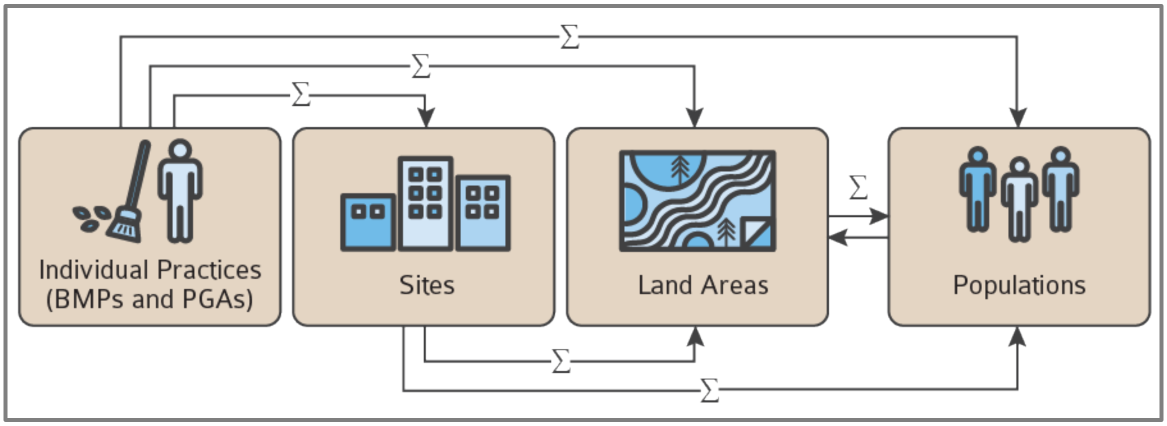


Figure 4.32: Potential Scales for Estimating Source Contributions

Relationships between each of these different scales have important implications for the way that source contributions can be approached. Most significantly, individual practices (BMPs or PGAs) can be "summed" across any of the other three scales. That is, source contributions for sites, land areas, and populations can all be calculated as the sum of the individual practices occurring within them. This relationship has broad-ranging and important implications because it's often not possible to develop reliable estimates directly at the site or land area scale. Population-based estimates in particular can be approached through the quantification of contributions associated with individual behaviors or practices (through surveys, inspection results, etc.). Results obtained at the site level can also be summed across land areas and populations.

Together, nature and magnitude provide a basic description of each source contribution. It's also important to consider how they vary in time and space.

Variability

Variability refers to how spread apart the measurements of source contributions within a distribution are, or how they vary from each other temporally or spatially. Not unexpectedly, the **temporal variability** of source contributions can also be quite significant. In fact this variability is likely reflected in that observed for many receiving water and MS4 conditions.

Looking at a hypothetical population of residences, it may be known that residents tend to wash their cars and do yard work more on weekends than during the week. However, while such generalizations can be useful in directing control strategies, they can also sometimes oversimplify (e.g., not everyone washes their cars on weekends). Understanding the variability of these behavioral patterns can lead to a more accurate prediction of when and where they may be generating source loadings. A control strategy that considers this variability is more likely to be effective.

Likewise it's important to define not only the contribution of a source type as a whole, but also which specific sources within that distribution provide the greatest contributions to MS4 and receiving water impacts. Outcomes rarely exist individually, i.e., they tend to be distributed within defined populations of outcomes of a particular type (e.g., the source contributions of all the residences within a jurisdiction, or of all the dog-walkers within a residential population, etc.). In a typical normally distributed population, the greatest numbers of individuals will be distributed toward the center of the distribution (i.e., grouped around the average value) and others toward the tails. To properly target control strategies it will be important to understand the degree of variability within a distribution and what it represents. In particular, sources that are the most prevalent or highly distributed throughout a drainage area, or portions of it, are more likely to represent significant loadings of flow or pollutants. As described above for MS4 contributions, statistically-based approaches can help to characterize and manage the variability associated with source contributions.

Collectively, nature, magnitude, and variability help to define the **significance** of a source contribution. Along with other factors considered below, significance plays an important role in determining whether or not a contribution is considered a problem, and if it is a priority for future action.

Certainty and Controllability

Certainty describes the confidence that managers have in their assessment of each drainage area or source contribution. Given the number of potential sources within a drainage area of interest, it's quite likely that many of them will not be characterized with a high degree of certainty. Because sources must often be approached as large populations (groups of people, of pets, of restaurants, of lawns, etc.), modeling and statistical approaches can be important in understanding their variability, and therefore in reducing the uncertainty associated with their respective contributions. An important informational gap that can contribute to uncertainty is a lack of knowledge regarding actual discharges from specific source types. As previously noted, managers often need to rely on estimates of **source potential** to determine the likelihood that a given source type will discharge flows or pollutants. This typically involves "profiling" the attributes (operations, PGAs, etc.) of specific source types, which may require the use of numerous untested assumptions. This can in turn lead to significant errors or a general lack of precision in estimating source potential. While these exercises are essential for planning, it's equally important to characterize the uncertainty associated with them and to address critical data gaps over time.

Controllability is the potential for a program to influence changes in a drainage area or source contribution. Management strategies should reflect an understanding of contributing sources and the presence of viable source control options for them. Controllability will be highly variable for different source areas or types. In general, highly regulated sources (e.g., construction and development) will tend to be comparatively more controllable than less regulated ones (residences, businesses that are not inspected, etc.). As such, portions of drainage areas that reflect a particular source composition, most typically expressed as differences in land use, are likely to experience similar differences in controllability.

Controllability also depends on the potential for intervention by the stormwater program. In some cases, available controls may be technically feasible, e.g., MS4 maintenance or installation of structural controls, but not within the resources of a program to conduct or impose. Controllability should therefore include a realistic assessment of the costs and program resources associated with each management option.

Analytical Approaches to Quantifying Source Contributions

Whether during planning or assessment, quantifying the loads or reductions associated with any source or source type is one of the most challenging aspects of stormwater management. This section briefly introduces several key considerations that can be useful in deciding how to approach quantification. Analytical approaches can be broadly classified according to monitored, modeled, and combined approaches.

1. **Monitored approaches**

Monitored approaches are empirical, and as such rely on sampling and observations as a basis for estimating source contributions. They include two important variants:

- Measurement of discharges, and
- Measurement of materials and wastes

Figure 4.33 provides an overview of these two approaches and provides examples of how they can be applied. As shown, monitored approaches can be desirable both for planning and assessment because they rely on actual measurements rather than assumed parameters. However, in practice, comparatively few program activities or controls provide directly measured data for use in source loading or reduction calculations.

The use of monitored approaches tends to be limited to individual practices or sites. However, in some instances where waste streams represent a "summation" across larger geographic areas (MS4 cleaning, household hazardous waste collection, etc.) results may have broader applicability. Monitored approaches can also be applied more broadly where individual results represent a statistically-based sample of a larger population of loads or reductions.

2. **Modeled approaches**

Rather than relying on direct measurement, **modeled approaches** infer loadings or reductions from the attributes, characteristics, or design of sources, drainage areas, or individual controls (behaviors, EMCs, design capacity, efficiency, etc.). Modeled approaches encompass a variety of tools, ranging from simple spreadsheets to sophisticated computer models. Spreadsheets can be important tools for generating basic planning input, especially where the data support needed for more complex models is lacking.

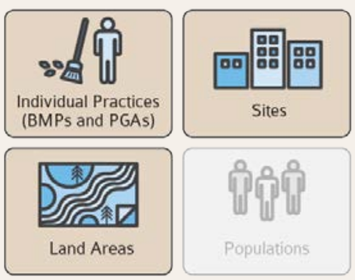
	A. Measurement of discharges	B. Measurement of materials and wastes
General Description	1. Loads or reductions are inferred from the quality and/or rates of effluent discharging from a point or a control. 2. Discharges at scales other than from individual BMPs (e.g., sites and land areas) are usually co-mingled with other discharges. 3. Measurement of effluents is direct, but to obtain an actual loading or reduction, conversions or adjustments are often required (e.g., extrapolation over multiple rainfall events, maintenance history, etc.).	1. Can apply in any situation where a material or waste is collected or quantified, e.g., street sweeping, MS4 cleaning, or collection of used oil, household hazardous waste, or trash. 2. Applicability is limited to waste streams within the physical possession of programs or regulated parties. 3. Measurement of materials is often direct, but to determine an actual loading or reduction, conversions or adjustments are often required (material-to-constituent conversions, assumptions about % of material likely to reach MS4, etc.).
Analytical Scale		
Potential Applications	• Structural treatment controls • Industrial facility monitoring • Land use monitoring	• Street sweeping • Creek clean-ups • Household hazardous waste collection • MS4 structural controls

Figure 4.33: Overview of Monitored Approaches to Evaluating Source Contributions

These are by far the most widely applicable approaches because they do not require direct access to data on the wastes or discharges associated with the source contributions under consideration. However, modeled approaches can often be very imprecise because of their heavy reliance on a variety of assumed parameters and values. In cases where estimates are calculated from multiple, sometimes poorly understood factors, the potential for propagation of error can be significant. In general, this makes modeled approaches more suitable for planning-level estimates or comparisons of source contributions, where precision is less critical.

The application of "pure" modeling approaches to the assessment of source contributions can be problematic because estimates built primarily on assumed parameters can't be reliably used as a basis for establishing baseline conditions or for measuring post-implementation reductions. As such, purely modeled approaches should be utilized primarily as planning tools, at least until a sufficient basis can be developed to support their use as assessment tools. **Figure 4.34** provides an overview of modeled and combined approaches and provides examples of how they can be applied.

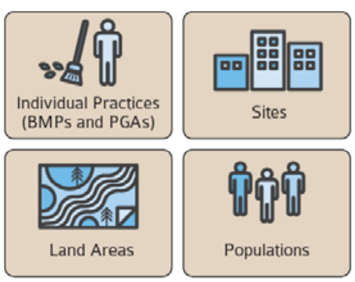
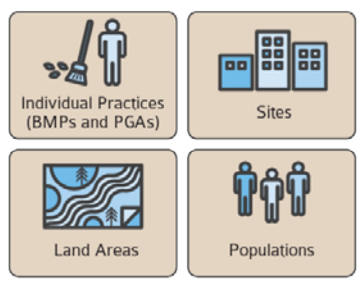
	Modeled Approaches	**Combined Approaches**
General Description	1. Loads or reductions are "constructed" from a variety of calculated or assumed parameters (implementation rates of PGAs or BMPs, rainfall patterns, runoff coefficients, BMP efficiencies, EMCs, material-to-constituent conversions, assumptions about % of material likely to reach MS4, etc.). 2. Particularly useful for planning. 3. Variety of tools available (simple spreadsheets, computer models, etc.).	1. Preferable to modeled approaches because they're partially supported by measurements 2. Also useful for planning. More useful than modeled approaches for assessment. 3. Measurement of materials can often be direct, but to determine an actual loading or reduction, conversions or adjustments are often required (material-to-constituent conversions, assumptions about % of material likely to reach MS4, etc.).
Analytical Scale		
Potential Applications	• All potential planning scenarios (including treatment controls, infiltration BMPs, source controls, and all examples in **Figure 4.29** above). • Not recommended for assessment.	• Same as for modeled approaches, but limited to applications where data from sampling or observation are available.

Figure 4.34: General Applicability of Modeled and Combined Approaches to Source Contributions

3. **Combined approaches**

In practice, most programs utilize a combination of modeling and monitoring approaches to estimating source contributions. **Combined approaches** often represent a useful compromise by bringing a moderate degree of data support to the more broadly applicable modeled approaches. One way this occurs is through the **validation** of monitoring parameters. That is, monitoring or other data collection is conducted to either support existing modeling assumptions or to "fine tune" them to a specific local application. Validation of assumptions is critical to reducing errors and improving accuracy over time. However, even a validated modeling approach can be somewhat limited in its application to actual assessment scenarios.

Another option is to combine available monitoring results with other assumed parameters. For example, a survey of restaurant operators might be conducted to characterize rates of key polluting behaviors. Results could be used in combination with other assumed parameters (numbers of applicable employees, loadings associated with key behaviors, etc.) to generate source contribution estimates that are partially data supported. By repeating this exercise in the future (or substituting other forms of observation such as inspection results), managers might be able to reasonably estimate loading reductions. Of course this type of exercise can also be highly speculative, but it illustrates an important pathway for improving source reduction estimates over time through the resolution of knowledge and data gaps.

Question 4 How are source contributions changing over time?

Source loadings are dynamic, and can sometimes change significantly over time. Knowing whether source contributions are **trending** upward or downward is critical to measuring program success. For example, are increases in hydromodification or pollutant loadings in receiving waters due to specific changes in source contributions? Trend analysis can be very useful in discerning these changes. To enable the evaluation of changes, it's important that a baseline of existing contributions be established, and that changes are tracked over time. Given the variety of sources within any drainage area, and the current state of knowledge for many of them, this can be especially challenging.

The outcome of **Task 1** will be the documentation of a variety of source contributions and associated attributes. Key drainage areas may have their own lists of corresponding source contributions. Results should be as inclusive as allowed by existing data and information. Where data are insufficient to fully describe a contribution or other source attributes, knowledge and data gaps should be documented for consideration in future data collection strategies. Identification of problem conditions will occur in **Task 2**. **Figure 4.35** provides a Review Checklist to guide the completion of **Task 1**.

Review Checklist

Step 4-A Task 1

Evaluating Drainage Area and Source Contributions

Apply this task very broadly across Outcome Level 4 sources of data and information. The purpose is to provide a "snapshot" of what is currently known about drainage areas and sources.

✓ **Compile existing data, information, and results applicable to Outcome Level 4. Consider the following questions:**

Question 1: Which drainage areas contribute pollutants and flows to MS4s?

Question 2: Which sources contribute pollutants and flows to the MS4?

Question 3: What are the current flow and pollutant contributions of drainage areas and sources?

Question 4: How are drainage area and source contributions changing over time?

✓ **Consolidate results into one or more summary lists of existing conditions. Categorize results as determined appropriate (by drainage area, source type, etc.).**

✓ **Compile supporting documentation for listed conditions.**

✓ **Select the conditions in the summary list(s) that will be further evaluated as potential problems in Task 2. Consider "back-up" lists for future evaluation as necessary.**

✓ **Document the critical data and information gaps identified during Task 1 completion.**

NOTES

Figure 4.35: Review Checklist for Evaluating Drainage Area and Source Contributions

Key Concept 4.2 Source Identification versus Source Characterization

As managers seek to identify the specific contributions of sources to MS4 and receiving water problems, it's important to understand the differences between source characterization and source identification. Source characterization seeks to understand the type and magnitude of constituents that may potentially be discharged to stormwater from a defined area or population such as high density residential land uses or auto repair facilities. Whereas a source identification study investigates the specific sources or activities associated with a measured constituent or impact within the MS4 or receiving waters.

For example, during MS4 assessment, a manager may have identified priority constituents such as copper that are related to receiving water problems. With limited data available on individual sources, they may first want to identify which land use types correspond to higher MS4 outfall concentrations and frequencies. Using GIS analysis or other available data sources, it might then be possible to determine which land areas have the highest potential for discharging copper to MS4 s and receiving waters. Further source characterization might also establish differences in the discharge potential of older, lower-density, residential land uses and higher density residential land use. These results may then help to focus source identification studies that will investigate the sources of copper within the lower-density residential land use that may include copper architectural features, gutters or roof flashing.

Source characterization and identification are not mutually exclusive, and may often complement each other. Managers may sometimes choose to first conduct source characterization as a means of informing subsequent more detailed source identification studies. For example, prior to initiating a source identification study, managers may also want to use available inspection and enforcement data along with GIS data to identify the likeliest contributing sources of copper and bacteria within the drainage area. This information can be useful in focusing a more detailed source investigation study. Given the potential costs and resources needed to conduct detailed investigations, this can be an important preparatory step. Results of both processes can be helpful in developing specific management strategies to abate source contributions.

The Source Profiles provided in Attachment B may also be used to help focus source characterization and identification initiatives.

Task 2 Defining Problem Drainage Areas and Sources

The objective of this task is to determine which of the drainage areas and sources identified above actually constitute problems. Two key questions guide this evaluation process.

Step 4-A Task 2 Key Questions

Defining Problem Drainage Areas and Sources

Inputs	Key Questions	Outputs
Drainage Area and Source Contributions & Characteristics	**Question 1:** Is the drainage area or source contribution causally linked to a known or suspected MS4 or receiving water problem? **Question 2:** Is there independent evidence for designating the drainage area or source contribution as a problem?	**Problem Drainage Area and Source Contributions**

Question 1 Is the drainage area or source contribution causally linked to a known or suspected urban runoff or receiving water problem?

Ideally the identification of problem drainage areas and source contributions will be based on the establishment of clear linkages to higher outcome levels. Problem contributions can be defined in relation to either MS4s or receiving water problems, or both. Determining a direct causal linkage between source contributions and higher level conditions can be based on a comparison of their common attributes. A comparison of sources to a list of priority constituents identified either for receiving waters or MS4s can sometimes elucidate problem source contributions. For example, if sediment in wet weather was identified as a priority water quality problem in a 303(d)-listed receiving water segment, and construction inspection data from upstream sites indicate issues with turbidity and TSS, it may be possible to establish linkages between both sets of problem conditions. Normally the most compelling evidence of a causal linkage will include data at the source, the MS4, and the receiving water, as well as a physical linkage between applicable drainage areas and MS4s. Likewise, linkages that are supported by statistical analysis are generally preferable to those established anecdotally.

Question 2 Is there independent evidence for designating the drainage area or source contribution as a problem?

This question acknowledges the practical reality that direct linkages between problem conditions are difficult to establish. Problem conditions must often be identified through other lines of evidence when drainage area and source contributions cannot be definitely linked to receiving water or MS4 problems. To illustrate, over-irrigation in a residential area cannot be directly linked to obseved MS4 or receiving water problems even though irrigation water discharges contain a number of constrituents above water quality benchmarks. Understanding that irrigation water discharges also create dry weather flows that provide migration pathways for these and other constituents, managers may elect to treat these discharges as priority contributions. Such linkages can also be consistent with the preventive approaches described above.

Ideally a linkage can be established to a specific portion of the MS4, but this isn't always possible. In such cases, it also makes sense to evaluate source contributions with respect to directly adjacent or downstream receiving waters. Even where a physical connection has not been established, constituent matches can be compelling. For example, if a receiving water is impaired for pyrethroids, a high level of urban uses of pyrethroids reported in the appropriate county would support additional consideration and investigation of a potential causal linkage.

The output of **Task 2** is one or more lists of problem source contributions. Results may include a range of confirmed or potential problems, and should be organized by drainage area. Drainage areas discharging significant flows or pollutant loads may also be designated as problems. Where data are insufficient to reasonably confirm a condition as a problem, it may be tentatively listed, and identified knowledge and data gaps considered for future data collection strategies. Prioritization of conditions will occur in **Task 3**.

Figure 4.36 provides a Review Checklist to guide the completion of **Task 2**.

Review Checklist

Step 4-A Task 2

Defining Problem Drainage Areas and Sources

Apply this task individually to each Task 1 drainage area or source contribution selected for further evaluation. The purpose of this task is to determine which of these contributions should be designated as problem conditions.

✓ **For each identified drainage area or source contribution, consider the following questions:**

Question 1: Is the drainage area or source contribution causally linked to a known or suspected MS4 or receiving water problem?

Question 2: Is there independent evidence for designating the drainage area or source contribution as a problem?

✓ **Document known or suspected drainage area or source problems.**

✓ **Consolidate results into one or more summary lists. Categorize results as determined appropriate (by drainage area, constituent type, source type, etc.).**

✓ **Compile supporting documentation for listed conditions.**

✓ **Document the critical data and information gaps identified during Task 2 completion.**

NOTES

Figure 4.36: Review Checklist for Defining Problem Drainage Areas and Sources

Task 3 Prioritizing Drainage Area and Source Problems

Starting with the list of drainage area and source contributions identified above, further analysis will determine which represent the highest priorities for directed action or additional study. A structured process can be helpful not only for identifying priorities, but for validating or refining existing ones. The key questions below are suggested to guide the prioritization of drainage area and source problems.

Step 4-A Task 3 Key Questions

Prioritizing Drainage Area and Source Problems

Inputs	Key Questions	Outputs
Problem Drainage Area and Source Contributions	**Question 1**: What is the priority rating of each drainage area or source contribution? **Question 2**: What is the relative importance of each drainage area or source contribution?	**Priority Drainage Area and Source Contributions**

As shown in **Figure 4.37**, prioritization is a two-step process. Each identified source contribution will first be reviewed to determine its **priority rating**. Ratings can then be considered together to determine their relative **priority ranking**. Given the number of sources likely to be identified, it makes sense to explore a variety of potential scenarios. However, it's also important to keep the number of potential priorities manageable.

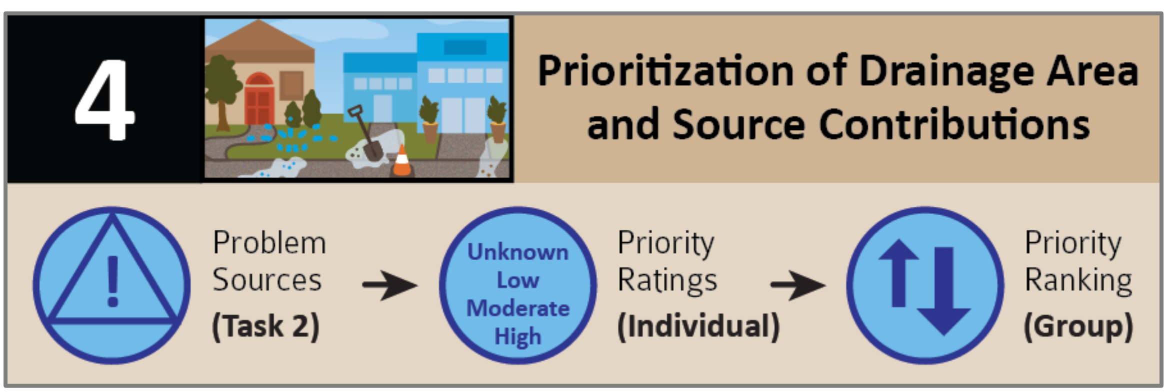


Figure 4.37: General Process for Prioritizing Drainage Area and Source Contributions

Question 1 What is the priority rating of each drainage area or source contribution?

Prioritization starts with the assignment of a priority rating for each drainage area or source contribution. Assignment of ratings relies primarily on the review factors identified in **Task 1** above. As shown, simple qualitative scoring methods are generally recommended throughout the rating process.

Tier 1 Regulatory Screening

Source contributions that can be directly linked to 303(d) listings, TMDLs, or permit requirements may need to be treated as higher priorities. **Figure 4.38** illustrates a Regulatory Screening process for nutrients in a residential drainage area. As shown, requirements and constraints are not significant, so their influence is relatively weak. The potential of requirements and constraints to offset each other should also be considered.

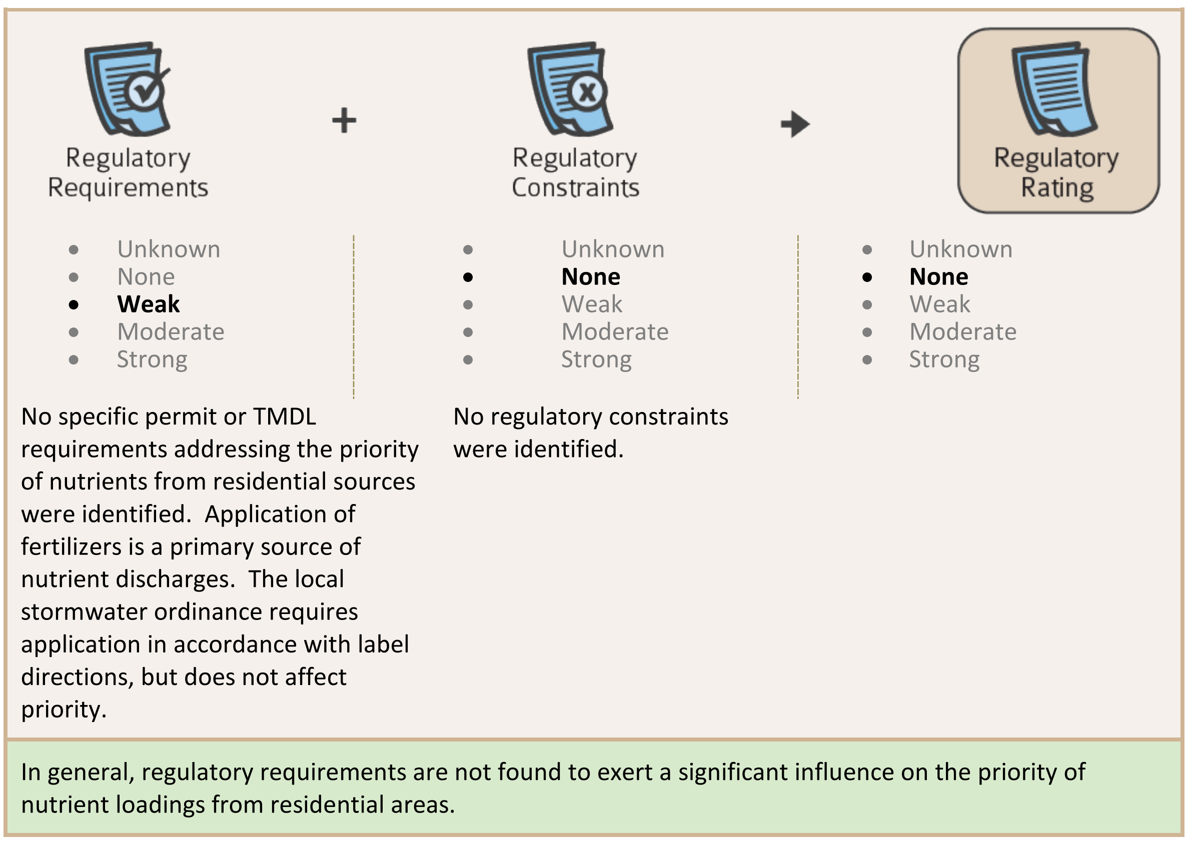


Figure 4.38: Establishing a Regulatory Rating for a Residential Source Contribution -- Nutrient Example[9]

[9] S = Strong, M = Moderate, W = Weak, N = None, U = Unknown. These are examples intended to illustrate potential rating designations.

Tier 2 Technical Review

Technical Ratings reflect a combined consideraion of three factors; significance, certainty, and controllability. The technical factors introduced in **Task 1** above (nature, magnitude, and varibility) combine to describe the **significance** of the source contribution (see **Figure 4.39**). As above, discretion is needed in scoring each of these factors due to the unique characteristics of each source loading scenario.

Evaluations of **certainty** should reflect an understanding of the precision associated with available data sources, or the methods used to analyze them. As an example, area-based pollutant loadings are often generated by applying Event Mean Concentrations (EMCs) for different land use types to a particular drainage area. Since EMCs are often derived from literature values, or from very limited local sampling, their use in estimating source or drainage area contributions can often be imprecise.

Nature +	Magnitude +	Temporal Variability +	Spatial Variability →	Significance
	• Unknown • Low • **Moderate** • High	• Unknown • Low • **Moderate** • High	• Unknown • Low • Moderate • **High**	• Unknown • Low • **Moderate** High
Wet weather monitoring data indicate nutrient exceedances of WQOs from residential areas.	Average values only slightly exceed the WQO for downstream receiving waters.	WQO is exceeded in 25% of sampling events.	Sampling over multiple years is broadly representative of residential sources within the drainage area. Exceedances are concentrated in 10% of sampling sites.	

An overall significance of **Moderate** is based primarily on magnitude. Temporal and spatial variability indicate that the contribution is neither persistent nor highly distributed. Additional investigation may be warranted in areas where exceedances are concentrated. Reevaluation of significance may be warranted only within those areas.

Figure 4.39: Establishing the Significance of a Residential Source Contribution -- Nutrient Example

While land area-based loading estimations are critical to planning, their use in prioritization and targeting should be approached with caution. Over time, they should be refined or augmented with other more precise indicators of source potential.

Controllability describes the potential to influence changes in a source contribution, primarily through the implementation of control measures. For any identified drainage area or source contribution, a variety of treatment or source control options may exist. Where they do, controllability will also depend on the ability of a program to direct resources to the problem, as well as that of regulated parties to implement identified solutions. Program resources and costs are therefore critical consideration in assesing controllability. Likewise, it can be dificult to control source contributions that are not well-understood (i.e., uncertain). In these cases, additional data collection may be needed to ensure that resource commitments are directed to the correct sources.

Figure 4.40 illustrates how significance, certainty, and controllability are jointly considered in the development of a Technical Rating using the same nutrient loading example.

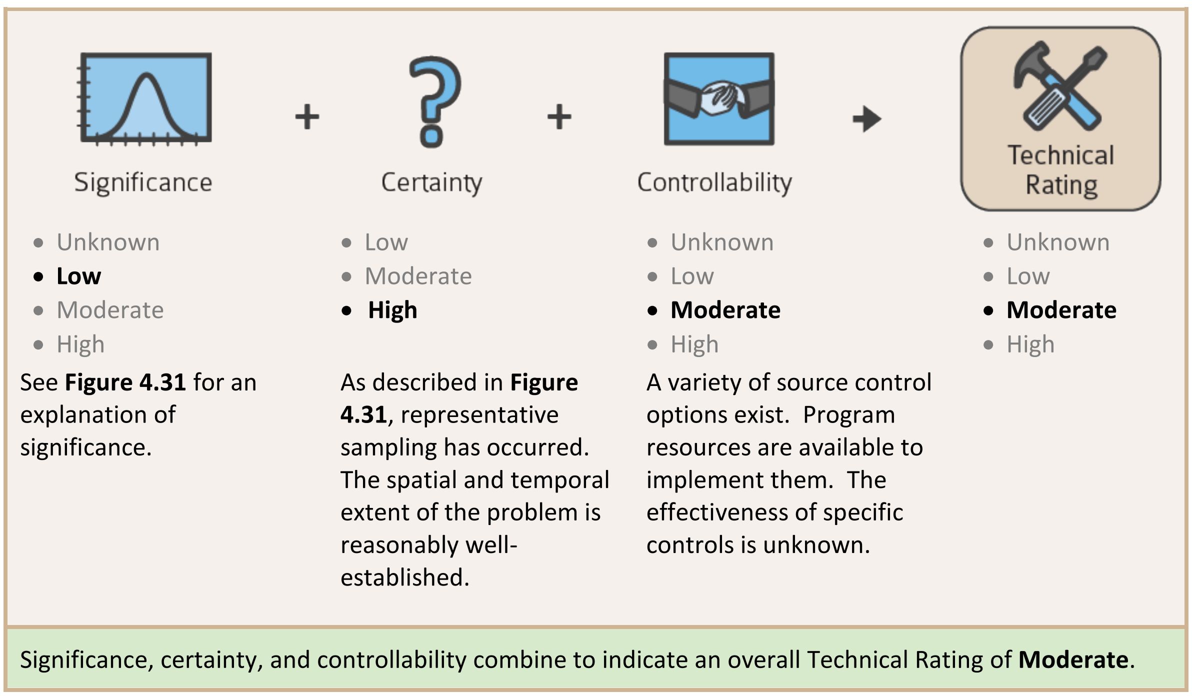


Figure 4.40: Establishing a Technical Rating for Residential Sources -- Nutrient Example

Tier 3 Sustainability Review

Wherever possible, prioritization should also consider social and economic factors. **Economic factors** are essential because both source loadings and reductions have costs associated with them. For example, if source loadings of bacteria are causing postings or closures of a receiving water, there is a cost associated with the reduction or loss of that beneficial use. Likewise, there the costs of implementing potential control strategies must also be considered. Depending on the specific source type, implementation costs are likely to be borne by regulated parties, stormwater programs, and possibly the public as a whole.

Social Impacts are those related to target audiences, society at large, or other specific segments. Perceptions and opinions regarding the implementation of potential control strategies can strongly influence priority. While the public generally expects to utilize and enjoy receiving waters, they will not always support the implementation of specific control measures needed to protect them.

Economic and social ratings may be developed individually, or a single combined rating may be developed for them together. Individual ratings would be a more likely choice in instances where managers want to give each factor greater overall weight to technical and regulatory factors. In most instances, knowledge of economic and social factors will be comparatively limited, so a single combined rating may be a more suitable choice.

Overall Priority Rating

As described in **Section 3.3 (Step A Task 3)**, Tier 1, 2, and 3 results are reviewed together to determine the **Overall Priority Rating** of each drainage area or source contribution. In the example shown in **Figure 4.41**, an Overall Priority Rating of High is assigned for residential loadings of nutrients.

As previously explained, equal weightings for all three sets of rating factors have been assumed. This is in keeping with the general recommendation made throughout this section to keep prioritization approaches as simple as possible. As described, simple qualitative approaches are generally appropriate given the lack of precision associated with most prioritization schemes. Discretion and judgment are necessary ingredients in the interpretation of results.

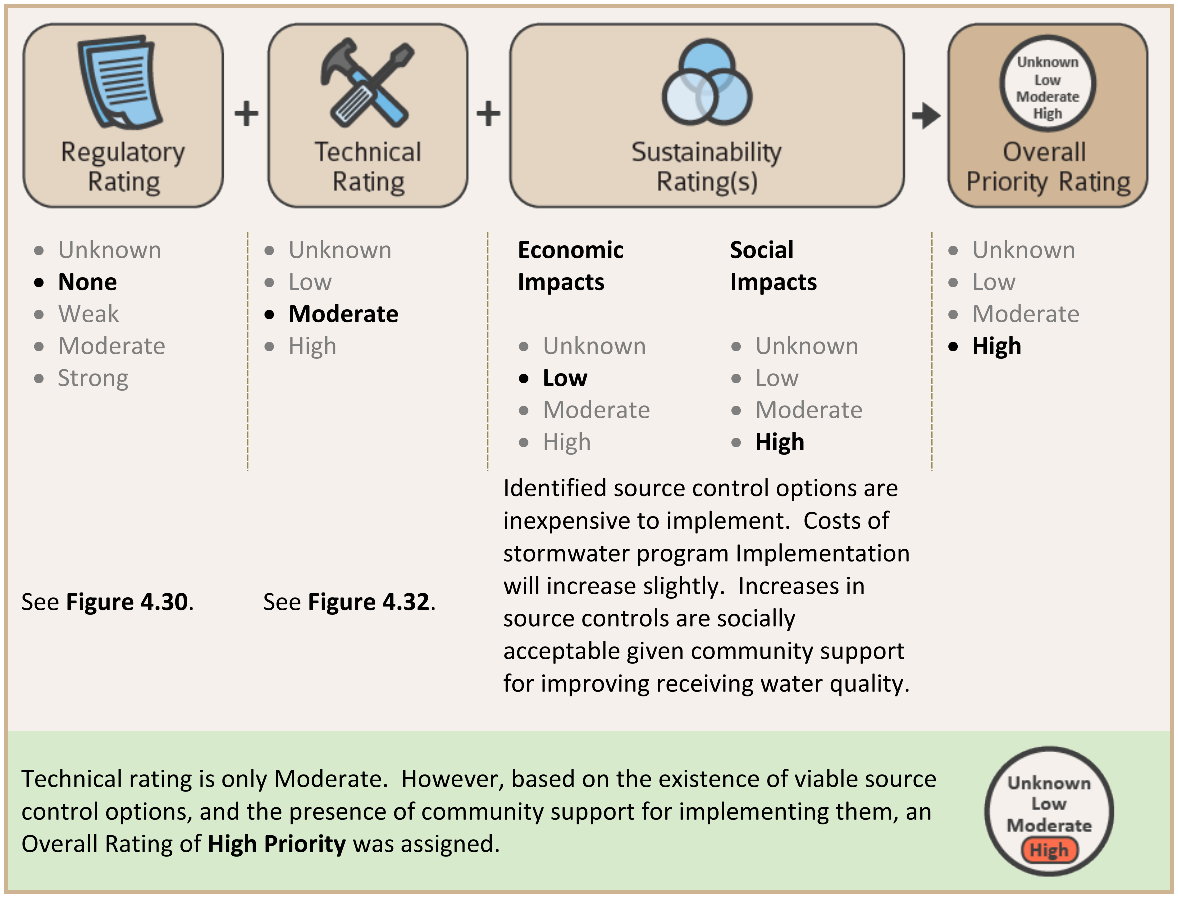


Figure 4.41: Establishing an Overall Priority Rating for Residential Sources -- Nutrient Example

Question 2 What is the relative importance of each drainage area or source contribution?

Individual priority ratings must now be evaluated together to determine their relative importance. Because programs must normally address a considerable number source contributions within any drainage area, considerations of scale are important. In some cases, managers will want to compare priorities across multiple drainage areas or source types (e.g., a comparison copper discharges from two drainage areas, or of several source types within a drainage area); in others, they will want to different types of contributions (e.g., copper versus bacteria) within a drainage area, or associated with a specific source type (e.g., industrial facilities or constructuion sites). All are legitimate analytical options, and may be pursued depending on the specific situation. For additional discussion on the significance of physical scale, see **Task 1, Question 2** above.

Two ranking options are illustrated in **Figure 4.42**.

Increasing Priority	RANKED ORDER EXAMPLE	GROUPED RANKING EXAMPLE
↑	1. Residential loadings of nutrients	**GROUP A (High)** • Residential loadings of nutrients
	2. Metals from industrial facilities	**GROUP B (Moderate)** • Metals from industrial facilities
	3. Bacterial loadings from improper	**GROUP C (Low)** • Bacterial loadings from improper
↑	4. Sediment loadings from construction sites	• Sediment loadings from construction sites

Figure 4.42: Potential Options for Ranking Source Problems within a Drainage Area

Identified problems can either be put into a **ranked order** or be **grouped** according to priority ratings. Establishing a ranked order consists of lining up the applicable problem conditions for each receiving water or segment from highest priority to lowest, with the higher priorities normally constituting the greater management priorities. A limitation to ranked order approaches is that receiving water problems may tend to have "tie scores". Using grouped rankings can reduce the need to conduct further analysis to differentiate between them.

Step 4 - B Targeted Changes to Source Contributions

Step 4-B addresses the establishment of measurable targets for drainage area and source reductions. As shown in **Figure 4.43**, it consists of three tasks, each of which is explored below.

Step 4-B begins with the list of **Priority Drainage Areas and Sources** established in **Step 4-A Task 3** above. Considering again the Drainage Area and Source Data and Information gathered for each condition on the list (**Step 4-A Task 1**), managers will establish specific, measurable targets and timelines for changes to be sought. For each identified priority contribution, one or more specific targeted reductions change should be considered.

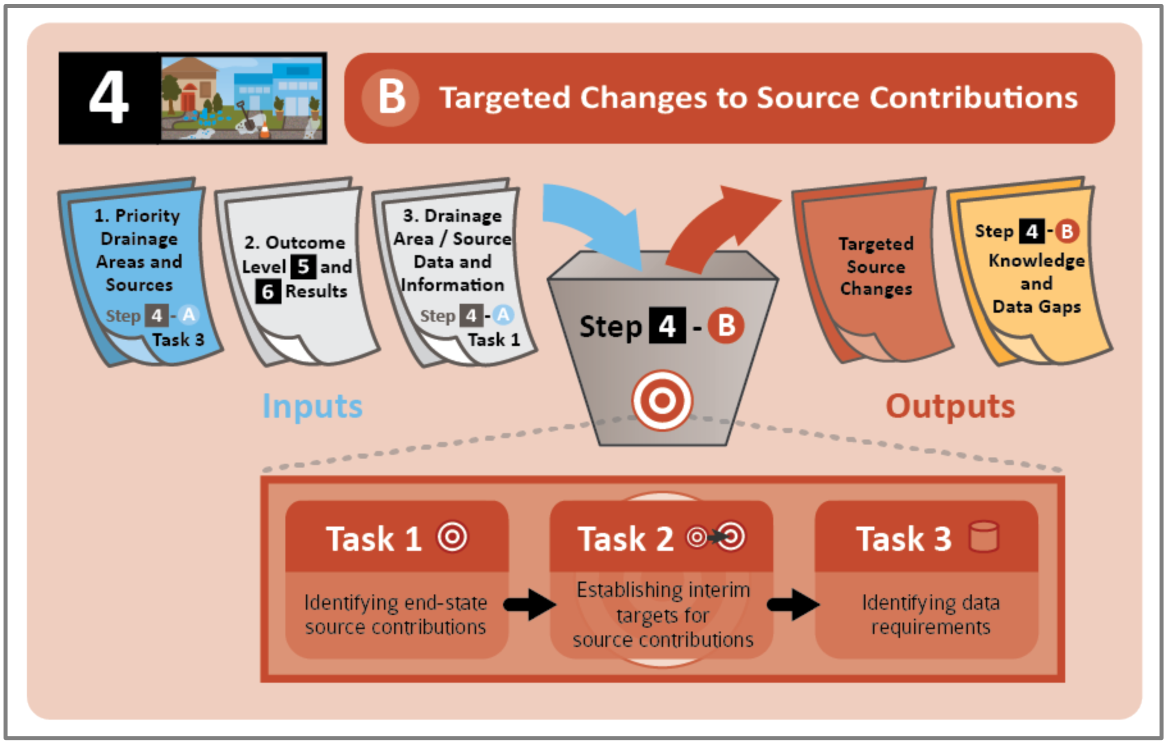


Figure 4.43: Targeting Changes to Source Contributions (Step 4-B)

Task 1 Identifying end-state targets

In **Step A**, users defined the nature and magnitude of individual problem conditions. In this task, they will focus on defining the changes to be sought in those conditions. It is guided by two general questions.

	Step 4-B Task 1 Key Questions Identifying End-state Targets	
Inputs	Key Questions	Outputs
Priority Source Contribution	**Question 1:** What is the end-state for the drainage area or source contribution? **Question 2:** When will the end-state condition be achieved?	**End-state Source Contributions**

Question 1 What is the end-state for the drainage area or source contribution?

End-state contributions are those that represent the absence of problems, or their reduction to acceptable levels. Targets for change should be considered at least for the highest priority contributions identified above. The establishment of targets should consider the review factors and general conceptual approaches described below.

Review Factors

Several review factors have general applicability in setting targets for drainage area or source reductions. As shown in **Figure 4.44**, these are the same general factors introduced above during problem prioritization.

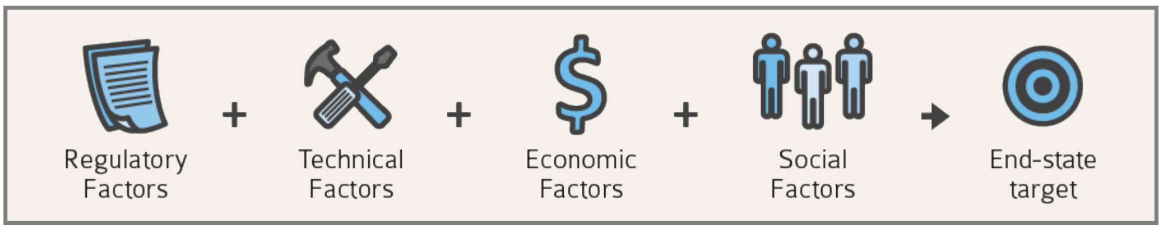


Figure 4.44: Factors Relevant to Setting Targets for Drainage Area and Source Reductions

Draft targets can initially be established through a consideration of the regulatory and technical factors introduced above (see **Task 4-A-3**), and these results further reviewed and refined as necessary in the context of sustainability considerations.

General Approaches to Establishing Targets for Drainage Area and Source Reductions

Targeting may follow any of the general approaches below, individually or in combination.

Setting Targets to Comply with Regulatory Requirements

Regulatory requirements can apply when setting targets for drainage area and source reductions. Sources or area-wide reductions that are specifically called out in Total Maximum Daily Loads will typically be treated as higher priorities. MS4 permits often establish priorities for specific source types, but normally do not establish corresponding requirements for specific reductions from them.

Setting Targets to Achieve MS4 and Receiving Water Improvements

For drainage area and source contributions, the end-state condition will ideally be the attainment of reductions that, in combination with other reductions, will reduce identified MS4 contributions to receiving water impacts. Given the many-to-one relationship of sources to MS4 and receiving water impacts, it's likely that many source reductions will be targeted concurrently. The critical consideration is not necessarily whether or not each target can be achieved, but rather their cumulative impact. Some targets will most likely not be achieved and others may be exceeded. Managers should also be realistic about the attainability of any targeted conditions, and of the timeframes needed to achieve and measure them.

It should also be noted that targeted changes other than source reductions may be sought within a drainage area to help bring about Level 5 and 6 improvements. For instance, changes in land use or zoning, retention of open space, and increases in infiltration can all potentially contribute to the reduction or mitigation of source contributions prior to their discharge to the MS4.

Setting Targets to Resource Availability

Given the wide array of sources potentially contributing to any MS4 or receiving water impact, resource limitations can make it especially challenging to effectively target source contributions. Since programs will not be resourced to achieve all identified reductions, decisions must to be made about how much and how quickly each of them can be achieved. While resource allocations will tend to be proportional to the relative priority of each contribution, other factors such as controllability and return on investment should also be considered. Resource allocations may also need to be concentrated in specific drainage areas rather than distributed evenly across them.

Setting Targets to Learn and Adapt

In some instances, targets may be established simply to explore the relationship of source contributions to higher or lower level outcomes, or the potential for achieving specific source reductions. **Experimental targets** are intended to establish and explore assumptions or hypotheses about these relationships.

Most of the time, the actual reductions that can be achieved will be unknown. For example, if managers might have a good idea of the specific behavioral changes they want to pursue in a priority target audience, but little idea of whether or not that might translate to a measurable source reduction. By establishing and tracking measurements for both types of outcomes, they may be able to increase measurability and establish linkages between them. One specific way of approaching this is through the establishment of **stretch targets**. Building on existing accomplishments, they can “stretch” to see what can be done cost-effectively or within available resource commitments (note the similarity of this approach to approach #3 above). This fosters an active learning process while pursuing increases in measurability that might later be used to explore linkages.

Interim targets are also critical to the learning process because they provide opportunities for obtaining feedback along the way toward end-state conditions. These are discussed further under **Task 2**.

Question 2   When will the end-state condition be achieved?

Every targeted source reduction will ideally specify the timeframe needed to achieve it. Some timeframes will already been established as permit or TMDL requirements. Managers should also consider how much time is needed to realistically achieve the change. While end-state receiving water conditions and MS4 can take decades to achieve (e.g., 20-50 years or longer; see **Figure 3.16**), it's expected that some source reductions can be acheived on shorter timeframes due the greater degree of direct control that can be exerted. However, in many cases, the inherit variability of many types of drainage area and source data will be unknown. Managers may therefore need to address significant data gaps before metrics and methods can be developed to forecast or measure source reduction with confidence. Likewise, allowances should be made for the time it takes to “ramp up,” refine, and fully implement the programs expected to drive these changes. Due to the speculative nature of forecasting these events, their establishment up front may not always be possible. Specificity and statistical certainty should always be a goal, but end-state timelines will often need to be established without them. In such cases, timeframes can be established provisionally, and then reviewed and modified as additional data, information, and results become available.

Table 4.19 provides a variety of examples of potential targets for end-state drainage area and source reductions. The uncertainty associated with many of these targets should be noted as this is often a prominent feature of the targeting process.

Table 4.19: Examples[10] of End-state Targets for Drainage Area and Source Reductions

Problem Condition	Priority	End-State Target	Explanation
Drainage Area Contributions			
Residential land uses discharge 414 lbs. of nitrates / year	High-Mod	Reduce nitrate loadings from residential areas by 45%	Because this is not a required reduction, it can be approached in combination with other programmatic stretch targets. This is an aggressive target that will require the initiation of a variety of control measures. Establishing measurability is key to learning which of them work and which don't.
Source Contributions			
Construction sites discharge sediment to MS4s	Moderate	Reduce sediment discharges by 10%	An existing baseline of contributions from which to measure has not been established.
Pet waste is estimated to represent 3% of bacterial loadings	Low	Reduce amount of pet waste in public parks by 75%	Reduction is focused in an area of high controllability. Loadings cannot be directly measured, so estimation of reductions must be approached through surveys and observations of staff.
Residential lawn watering contributes 23% of dry weather flows to MS4 outfalls	Moderate	Reduce overwatering by 20% (volume)	20% reduction in existing contribution represents 4.6% of the total. Other contributions would likely need to be concurrently targeted.

[10] These examples are hypothetical and for illustration only. They are not intended to imply a particular target or timeline for achieving any of the conditions listed.

Task 2 Establishing interim targets

Every targeted end-state condition will have a timeframe associated with it. Since many of these can take years, decades, or longer to achieve, a course of action will normally need to be set for incrementally achieving them. The establishment of interim targets follows two guiding questions.

Step 4-B Task 2 Key Questions
Establishing Interim Targets

Inputs	Key Questions	Outputs
End-state Targets	**Question 1:** What interim targets are needed to evaluate progress toward end-state drainage area or contributions? **Question 2:** When will interim targets be achieved?	**Interim Targets**

Question 1 What interim targets are needed to evaluate progress toward the end-state drainage area or source contributions?

Interim targets are routinely established in TMDLs, and many MS4s permits and permit-required watershed plans are increasingly setting specific timelines for achieving change. Change is not linear, so managers should be realistic about how quickly they can expect source reductions to change. As previously described, a challenge in establishing interim milestones is the ability of managers to forecast the implementation curve associated with targeted changes (e.g., time to "ramp up," refine, and fully implement programs). Given this complexity, the forecasting of specific events in that curve can be speculative, and may not always be possible. In such cases, targets and timeframes can be established provisionally, and then reviewed and modified as additional data, information, and results become available.

Interim targets for source contributions may include achieving a percentage of the end-state target, or focusing on reductions within a specific drainage or set of priority drainage areas. Targets should also consider the level of effort needed to achieve a target given the understanding of the contribution, existing control strategies, and resources available to address them.

Question 2   When will interim targets be achieved?

Timeframes for acheiving interim drainage area or source reductions will initially be bounded by the schedules set for achieving end-state reductions, but should also reflect the need for specific feedback along the way. At a minimum, they should reflect the time needed to achieve critical events in the projected “implementation curve” described above. For sources addressed under a TMDL, or where MS4 permit conditions are prescriptive, interim targets and timelines may already be established.

Interim targets should be set to timelines that reflect both the time needed for projected changes to occur and for statistically valid measurement. As such, they should also account for the inherent variability of drainage area and source data. Since many applicable source-related data sets will not yet have been established, variability may often not be known. It's therefore important that source-related knowledge and data gaps continue to be addressed. As for other outcome levels, the commitment of resources to drainage areas and sources based on limited or anecdotal informaton should be approached with caution. Reasonable statistical support for the evaluation of end-state and interim targets should always be a goal. This issue is especially critical for interim targets because the timeframes needed for data collection and analysis are much shorter.

Task 3 Identifying data requirements

Now that targets for source reductions change have been identified, it's necessary to identify how they will be measured, what data are needed to allow measurement, and how these data will be collected and analyzed. Planning is not complete unless managers are fully prepared to obtain and evaluate the data needed to assess each targeted change. Each of the questions below should be addressed for every targeted outcome addressed in **Step 4-B**.

Question 1   What metrics will be used?

End-state and interim source reductions should both be expressed in unambiguous terms. This should include a specific formulation of the outcome statement, the assignment of units of measure or assessment, and units of time. **Section 7.3** provides additional detail on the establishment of metrics.

Question 2   What data collection methods will be used?

It's also essential that managers identify how data will be collected for each targeted source reductions so that it can be tracked and assessed. **Section 7.4** provides additional detail on potential data collections options.

Question 3   What data analysis methods will be used?

The last consideration for any targeted source reductions is how the data will be evaluated. The choice of analytical method can dictate what specific metrics should be used, how the data should be collected, and the quality of the result. **Section 7.5** provides additional discussion of data analysis options.

Figure 4.45 provides a Review Checklist to guide **Step 4-B** completion.

Review Checklist

Step 4-B Tasks 1, 2, and 3

Targeted Changes to Source Contributions

Apply this task individually to all conditions selected for targeting in Step 4-B. Its purpose is to identify specific targets for change in these conditions.

✓ **End-state Targets (Task 1)**
Consider the following questions:

Question 1: What is the end-state for the drainage area or source contribution?

Question 2: When will the end-state condition be achieved?

✓ **Interim Targets (Task 2)**
Consider the following questions:

Question 1: What interim targets are needed to evaluate progress toward end-state drainage area or contributions?

Question 2: When will interim targets be achieved?

✓ **Data Requirements (Task 3)**
Consider the following questions:

Question 1: What metrics will be used?

Question 2: What data collection methods will be used?

Question 3: What data analysis methods will be used?

✓ **For each priority source contribution, document interim and end-state targets, and the data requirements necessary to track and evaluate them.**

✓ **Compile one or more lists of targeted source reductions and supporting documentation for listed conditions.**

✓ **If a priority source reduction is not or cannot be targeted, document the reason.**

✓ **Document all Step B data and information gaps.**

NOTES

Figure 4.45: Review Checklist for Targeting Source Reductions

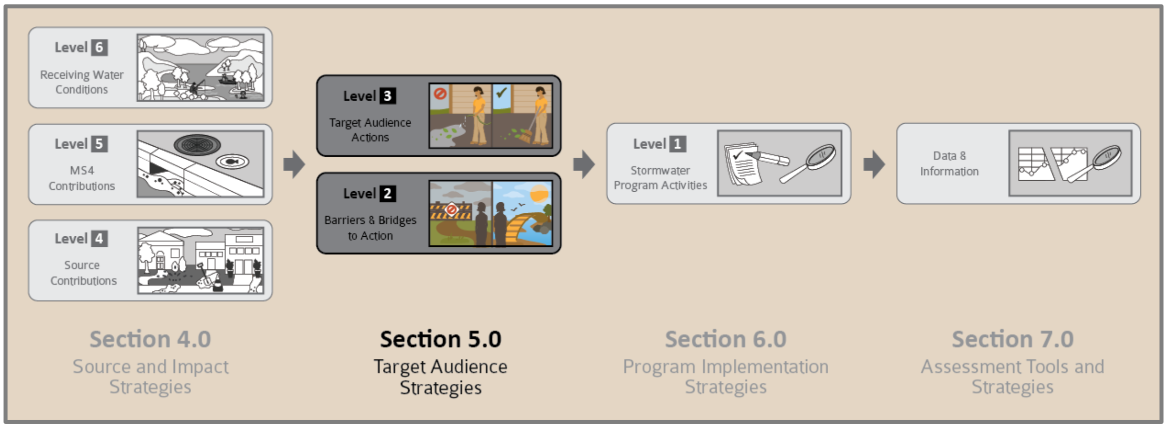
Step 4 - C Documenting Knowledge and Data Gaps

The identification of knowledge and data gaps should be ongoing throughout the entire Level 4 planning process. At its conclusion, managers should have developed a list of gaps that can be incorporated into a Monitoring and Assessment Strategy. **Section 7.0** provides additional guidance on assessment tools and strategies to support the development of these strategies. Because an existing baseline of data and information does not exist for many sources, Level 4 knowledge and data gaps can be significant. Critical gaps must be addressed to ensure that they are resolved over time. **Table 4.20** provides examples of general areas of inquiry where Level 4 knowledge and data gaps are likely to be encountered. These are intended to provide a framework for identifying actual knowledge and data gaps, which will be much more specific than those listed here.

Table 4.20: Potential Areas of Drainage Area and Source Knowledge and Data Gaps

- ✓ Understanding of drainage area contributions (EMCs, monitoring data, methodologies, etc.)
- ✓ Understanding of drainage area attributes (land uses, areas of pollutant and flow generation, population distribution, etc.; see also **Table 4.14**)
- ✓ Understanding of source contributions (potential or actual wet and dry weather discharges of pollutants or flows)
- ✓ Understanding of source attributes (number, size and types of sites or facilities; activities and practices; operations conducted; materials and wastes; see also **Table 4.15**)
- ✓ Adequacy of facility or other monitoring data (sample size, representative sampling, etc.)
- ✓ Knowledge of target audience attributes
- ✓ Knowledge of economic and social factors affecting drainage areas and sources

Section 5.0 Target Audience Strategies



*This section describes the development of **Target Audience Strategies**, the second of four strategic planning components introduced in Section 3.0. Following the identification and prioritization of source contributions described in Section 4.0, target audience planning addresses Outcome Levels 3 and 2. Managers will focus on identifying the people that are responsible for these contributions, and then on characterizing the specific behaviors attributable to them. Ultimately, they will need to know how people should be acting differently and develop a clear understanding of the factors that may be standing in the way of desired changes.*

Completed Target Audience Strategies will inform the subsequent development of Program Implementation Strategies in Section 6.0, and will inform the subsequent development of Assessment Tools and Strategies in Section 7.0.

5.1 Background

To bring about changes in runoff or receiving water quality, managers must focus their efforts on the people responsible for source discharges. **Target audiences** are the groups or individuals that programs are directed to (e.g., residents, schoolchildren, construction contractors, business operators, or municipal employees). Each of the priority source types identified in **Section 4.0** will have one or more target audiences associated with it. Most often, program activities will be directed to the primary target audiences directly responsible for source contributions, i.e., those engaging in pollutant generating activities (PGAs) or with the potential to implement best management practices (BMPs). But managers sometimes also need to address secondary target audiences that can play a supporting role in bringing about change (e.g., by conducting industry trainings, or reporting pollution). This section deals with identifying and characterizing the attributes of target audiences, and in understanding their behaviors and the factors that influence them.

This section addresses the **PEOPLE** responsible for the source contributions discussed in **Section 4.4**, the behaviors that contribute to them, and the factors that influence behavioral patterns.

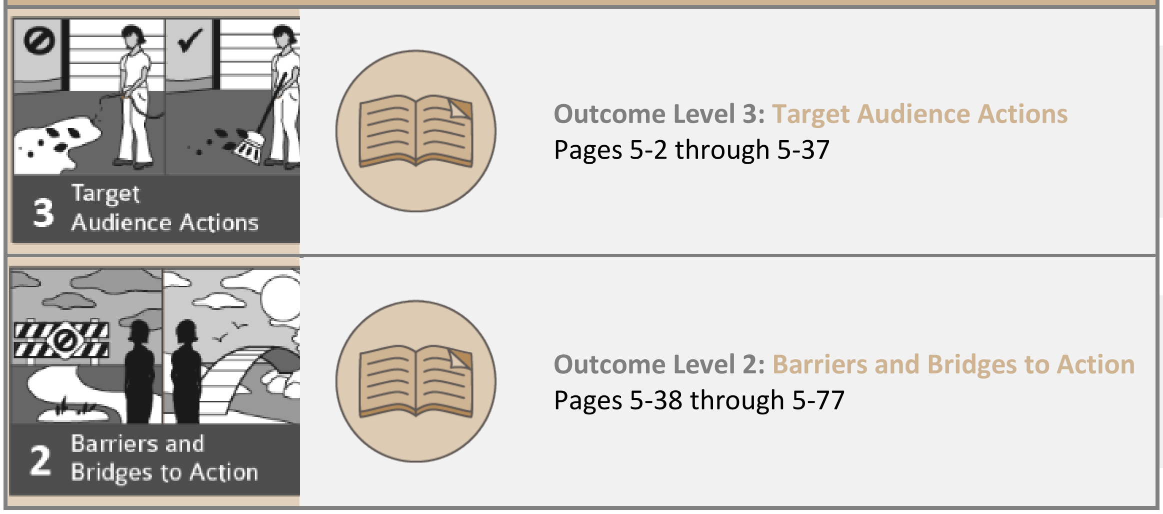
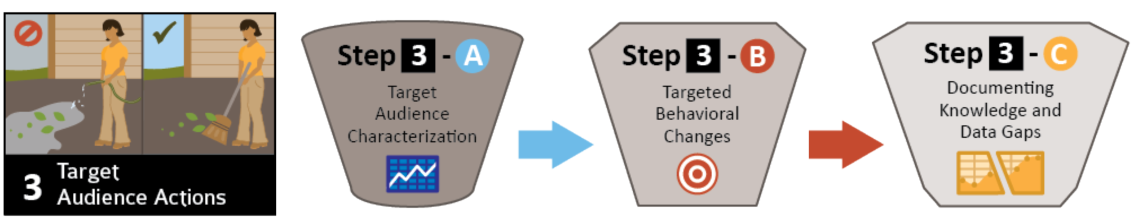


Figure 5.1 Primary Components of Target Audience Strategies

5.2 Outcome Level 3: Target Audience Actions

Water quality improvements can usually be achieved only when specific actions have occurred in one or more target audiences. The methods and approaches described in this section follow the premise that a combination of target audience actions is needed to materially affect these changes. Selection of target audiences is one of the most crucial parts of the strategic planning process.



As shown here, Level 3 planning consists of three steps. In **Step 3-A** managers will identify, prioritize, and learn as much as they can about the target audiences that they believe are responsible for the identified priority source contributions. This will initially include looking into their behavioral patterns, but further consideration of other attributes (gender, ethnicity, income, education, etc.) will also help to provide a basis for later planning steps. Once priority target audiences and behaviors are identified, specific changes in them will be targeted in **Step 3-B**. Finally, since detailed data and information on target audience behaviors are often likely to be lacking, knowledge and data gaps will be summarized and documented in **Step 3-C**.

Step 3 - A Target Audience Characterization

The purpose of this step is to determine who stormwater program activities should be directed to, and to characterize their behaviors and general attributes. As shown in **Figure 5.2**, target audience characterization consists of three tasks. Characterization begins with the identification of the people who are responsible for identified source contributions. Target audience behaviors will then be identified and narrowed to those considered to represent problems that may warrant resource commitments.

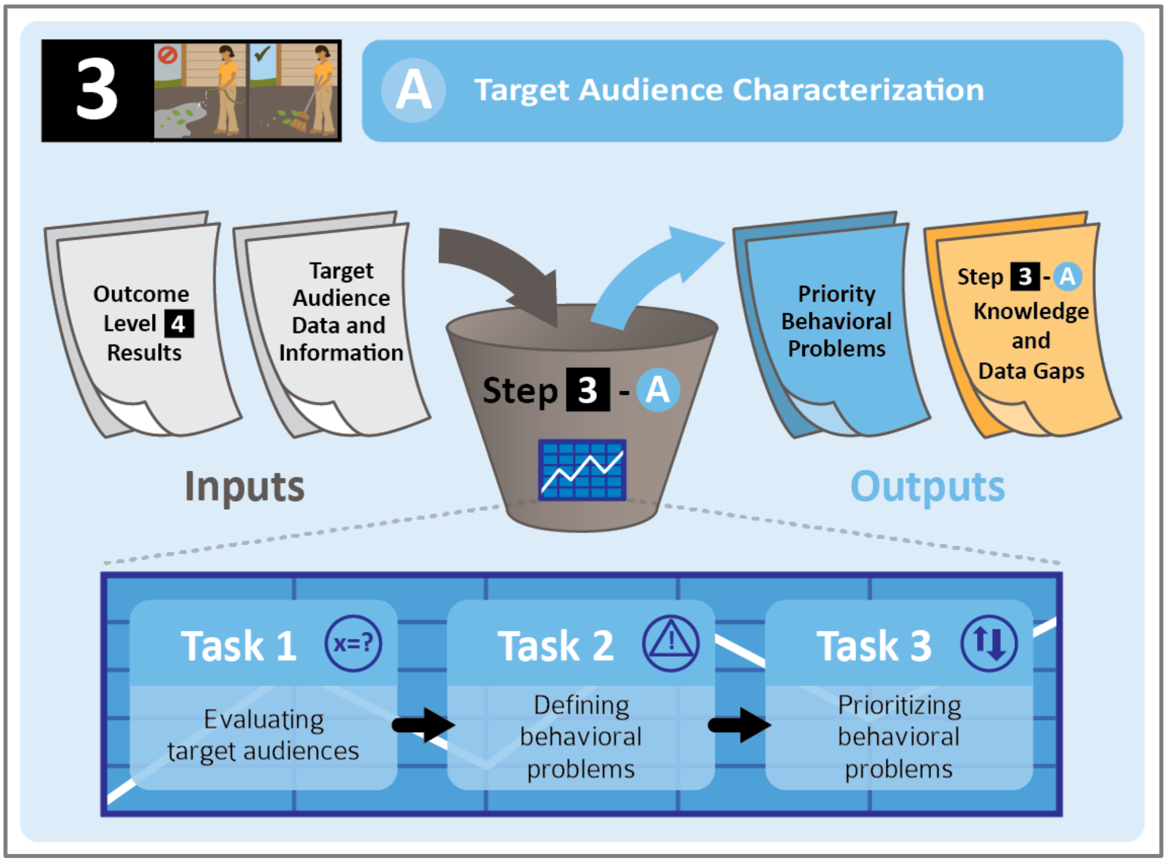


Figure 5.2: Target Audience Characterization (Step 3-A)

Table 5.1 identifies many of the inputs that can inform Level 3 strategic planning. The first of these are Level 4 planning results, which can include any of the items listed. Source priorities will already have been at least provisionally identified, but may change as new information is considered during Level 3 planning. Likewise, potential target audiences that may have already been identified should be considered further. A variety of other sources, e.g., inventories, surveys, and historical compliance results, can also help to provide insight into target audiences.

Table 5.1: Potential Inputs for Level 3 Strategic Planning

Outcome Level 4 Planning Results

- ☑ Priority source(s)
- ☑ Source characteristics (pollutant loadings, hydrology, and other)
- ☑ Potential target audiences (if identified)
- ☑ Outcome Level 4 knowledge and data gaps

Other Target Audience Data and Information

- ☑ Existing programs (annual reports, records and documentation, etc.)
- ☑ Interviews, surveys, tests, and quizzes
- ☑ Facility or site inspections
- ☑ Complaint investigations
- ☑ Pollution reports and referrals (hotline, employee, contractor, etc.)
- ☑ Third parties (submission of compliance data, maintenance records, etc.)
- ☑ Business, site, facility databases (Tax assessor, Dunn and Bradstreet, etc.)
- ☑ Population, demographic data (census bureau, associations of governments, etc.)
- ☑ Business, employee associations and organizations, homeowner and renters associations
- ☑ Other regulatory programs (hazardous materials, fire, recycling, planning, etc.)
- ☑ GIS, aerial photography, land use maps, etc.
- ☑ Special investigations (community-based social marketing studies, etc.)
- ☑ Published or unpublished research, literature, and technical reports (CASQA BMP Manuals, etc.)
- ☑ Other (TBD as needed)

Task 1 Evaluating Target Audiences

Managers will first identify and evaluate the target audiences with the potential to impact priority source contributions. At this point all potential target audiences should be of interest. Data and information will initially be reviewed to address the four key questions below for each potential target audience. This process needn't be repeated in its entirety for every target audience since they can often be similar or the same for multiple source types.

Step 3-A Task 1 Key Questions
Evaluating Target Audiences

Inputs	Key Questions	Outputs
Available Data, Information, and Results	**Question 1:** Which target audiences are associated with priority source contributions? **Question 2:** What are the behavioral patterns of target audiences? **Question 3:** How are behaviors changing over time? **Question 4:** What are the characteristics of target audiences?	**Target Audience Behaviors and Characteristics**

Question 1 Which target audiences are associated with priority source contributions?

Once priority source contributions have been identified, it's necessary to know who is responsible for them. This can initially be approached by considering the target audiences associated with general source categories and types. It's helpful to consider how target audiences differ from populations. A **population** is any group of people within a defined area or sharing one or more common attributes (race, gender, class, etc.). A **target audience** is a group of people that stormwater program activities are directed to. While the two can be the same, often they are not. For instance, the residential population within a jurisdiction may be segmented into multiple target audiences (schoolchildren, renters, dog owners, automotive enthusiasts, etc.), each potentially requiring completely different intervention strategies.

It's important to be specific when defining target audiences since any of them can have vastly different characteristics and polluting behaviors. A good place to start is with the broad source categories previously identified in **Section 4.2**. As shown in **Table 5.2**, each of these has a number of specific target audiences potentially associated with it.

- **Residential target audiences** tend to be large and varied, so segmentation according to common characteristics or traits (home ownership, hobbies, income levels, ethnic background, etc.) can be important. This contrasts with other source categories, where target audiences are aligned primarily with places of employment and specific job responsibilities. It can take some additional effort to determine how to segment residential target audiences.

Table 5.2 Examples of Target Audiences by General Source Category

Residential Sources	
Do-it-yourselfers (e.g., gardening and yard care; home improvement; power washing; vehicle washing, maintenance, and repair) Service providers (commercial operations corresponding to same activities as above)	Pet owners Livestock owners Smokers Recreational water users (swimmers, surfers, etc.) Schoolchildren Hotline callers
Municipal Sources	
Garbage collectors Street maintenance staff Park and grounds maintenance staff Building maintenance staff Grading plan or permit reviewers Grading or construction inspectors Industrial and commercial business inspectors	Waste water collection and water distribution maintenance staff Animal control staff Law enforcement staff Flood control or reclamation district maintenance staff Hazardous materials inspectors
Industrial and Commercial Sources	
Owners Managers and supervisors Employees (skilled workers and laborers)	Mobile operators Contractors (landscaping, parking lot sweeping, etc.) Industry associations Employee unions
Construction Sources	
Owners Developers Planning groups	Contractors (plumbing, etc.) Skilled workers Laborers
New Development and Redevelopment Sources	
Engineers and architects Landscape architects Urban planners Engineers	Developers Housing authorities Flood control or reclamation district planners

- **Municipal target audiences** correspond to sources and activities that are usually under the control of government or agency employees, contractors, or leaseholders. The specific job functions of these parties normally define their potential for polluting and the roles they play in implementing controls. Field personnel generally have a direct role in implementing BMPs, but supervisors, managers, and office workers can also contribute in a variety of ways (e.g., scheduling activities, conducting training, or obtaining support from elected officials).

- **Commercial and industrial target audiences**, while different in their functions, are similar to those for municipal sources. Roles and responsibilities typically correspond closely to specific job functions. A challenge for addressing commercial and industrial businesses is that they vary widely according to business type. Industry associations can play an important role in supporting BMP implementation through activities such as regulatory tracking and advocacy or providing education and training.

- **Construction target audiences** are often responsible for very different pollutants and impacts than those associated with existing development. Specific target audiences are diverse. While field personnel are usually directly responsible for on-site activities, managers, site supervisors, inspectors, and owners can all play a role in supporting or implementing BMPs.

- **Land development target audiences** are those associated with the permanent post-construction features of new development and redevelopment sites. Examples include engineers, architects, planners, and transportation and housing authorities.

Additional segmentation and refinement of target audiences will be possible as behavioral patterns and other attributes are identified throughout the remainder of this task.

Question 2 What are the behavioral patterns of target audiences?

Although other target audience attributes will be explored later, managers should start by evaluating their behaviors. Since behavioral patterns define the potential of a target audience to generate source contributions, defining them up front can prevent unnecessary effort later. Other attributes can be considered later once it's determined that the target audience is of continued interest.

Types of Target Audience Behaviors

To understand behavioral patterns, it's first necessary to look at the nature of the behaviors themselves. Target audience actions can be considered according to three general categories. These are introduced in **Table 5.3** and explored in detail below.

Table 5.3: Three Primary Types of Target Audience Actions

	**Pollutant-generating activities (PGAs)** are behaviors that contribute pollutants or increase flows to runoff. In this illustration, a woman is using a hose to clean up an outdoor area. If other precautions are not taken to prevent flows and pollutants from leaving the site, this action is likely to be a PGA.
	**Best management practices (BMPs)** are practices designed to prevent, reduce, or eliminate discharges of pollutants and flow. Here the woman has instead chosen to use a broom for cleaning up. Dry sweeping methods are an excellent example of choosing a BMP over a PGA.
	**Supporting behaviors** are actions that encourage or facilitate BMP implementation. Supporting behaviors can be initiated by virtually anyone; in some cases, by dischargers (facility self-inspections, staff training, etc.) and in others by interested parties (pollution reporting, joining an environmental advocacy group, etc.).

1. **Pollutant-generating Activities (PGAs)**

PGAs are the behaviors that contribute pollutants to runoff (i.e., rinsing off a sidewalk or other surface with material such as sediment, trash, or vegetation on it). Their reduction or elimination is the primary focus of stormwater management programs. PGAs are not always the result of current behaviors. Sometimes they existing features that have resulted from past practices, or in other instances discharges that are not directly attributable to a specific behavior. Examples include erosion of exposed areas, deposits of legacy pollutants (e.g., PCBs), and overland discharges from large areas. For simplicity, the term PGA is used to describe any current activity or existing feature that generates pollutants or flows. It's important to consider all likely PGA contributions in developing BMP implementation strategies.

Because PGAs tend to be situational and location-specific, a definitive classification of them does not exist. Anything with the potential to contribute pollutants or increase flows to runoff can be a PGA, and our understanding of them is constantly evolving. **Table 5.4** provides an overview of potential PGA types associated with a range of sites, facilities, and operations. It should be emphasized that none of these activity types represents an actual PGA unless it is implemented in a way that results in a discharge of pollutants or flows. In practice, managers must often direct program activities to suspected or potential PGAs under the assumption that they are actually causing discharges.

In evaluating potential PGAs, it's important to consider the specific pollutants or stressors associated with each. Since source loadings are defined by the collective input of all applicable PGAs, managers will need to consider which ones are contributing to specific pollutant or flow impacts, and what the relative impact of each is. It can sometimes be challenging to determine this with confidence since our knowledge of PGAs is often based on a general knowledge of the activities rather than actual data on discharges.

General PGA profiles can be extremely helpful for understanding their relationships to specific pollutants or stressors, but managers should be aware of the difference between potential and actual generation of pollutants. Just because a PGA has the potential to discharge a pollutant doesn't mean that it does. Overly-inclusive assumptions about polluting potential based solely on general profiles can result in program resources being directed where they may not be contributing to the resolution of an actual problem. Despite the importance of standardized information, managers should continually seek to expand their knowledge of specific PGA discharges. Where they are obtainable, local site-specific data should always be preferable to standardized profiles. It may be necessary to address such gaps as part of future data collection strategies.

1. **Best Management Practices (BMPs)**

Best Management Practices are activities or other controls that are implemented to reduce or eliminate discharges of pollutants and flow. BMPs can take a variety of forms (source controls, treatment controls, prevention, infiltration, etc.), all of which may be considered as potential alternatives to PGAs. The substitution of BMPs for PGAs can be a key measure of program success. Stormwater Management Programs seek to bring about the implementation of a wide variety of structural and non-structural BMPs by target audiences. Specific examples include picking up after pets, modifying irrigation or pest control practices, slope stabilization, and treating runoff with structural controls.

Table 5.4: Examples of Potential Pollutant Generating Activities (PGAs)

Materials and Wastes

Materials Management, Storage, and Disposal

- Materials loading & unloading
- Liquid container storage
- Outdoor storage of raw materials, products, & byproducts

Waste Handling, Storage, and Disposal

- Hazardous waste
- Solid waste
- Food grease and oil
- Pet waste and manure
- Liquid waste
- Sanitary waste
- Green Waste
- Recyclable & reusable materials

Vehicles and Equipment

Vehicle and Equipment Fueling

Vehicle and Equipment Storage

- Outdoor vehicle storage
- Outdoor equipment & parts storage

Vehicle and Equipment Washing and Cleaning

- Vehicle washing
- Equipment cleaning

Vehicle and Equipment Repair, Maintenance, and Servicing

- Vehicle & equipment maintenance
- Vehicle & equipment repair
- Changing vehicle fluids
- Outdoor process equipment operation & maintenance

Outdoor Areas (Use, Operation, Maintenance, Repair, and Construction)

Buildings and Grounds

- Landscaping & gardening activities
- Pesticide & fertilizer application
- Pool, spa, and fountain maintenance
- Rooftop & downspout maintenance
- Sidewalks, break areas, & public areas
- Pressure washing
- Contaminated or erodible surfaces
- Earth moving activities

Parking Areas and Driveways

- Use & Maintenance
- Sweeping & cleaning

Driveways, Roads, and Streets

- Road and Street Use and Maintenance
- Driveways

Storm Drain Systems

- Storm drain operation & maintenance
- Treatment control BMP maintenance
- Illicit discharges & connections

Other Specific Operations and Activities (Examples)

- Animal grooming & washing
- Casting, forging, or forming
- Chemical treatment
- Fire sprinkler testing & maintenance
- Cutting, trimming, or grinding
- Dust & particulate-generating activities
- Fabrication
- Fire hydrant, tank, & hose testing and maintenance
- Floor, mat, & surface cleaning
- Food preparation
- Mixing
- Painting or coating activities
- Pesticide / chemical product formulation
- Recreational uses
- Special events
- Wastewater treatment
- Weed abatement / vegetation clearing
- Welding

In many instances, a basic understanding of BMP implementation (rates, efficiency, etc.) is necessary to estimate source loadings from a site or facility. BMP Implementation is one of the most important objectives of a Stormwater Management Program since it represents a crucial linkage to Level 4 outcomes. That is, reductions in pollutants or flows from targeted sources can't be estimated without some understanding of BMP implementation. **Table 5.5** introduces and briefly describes the major categories of BMPs.

Table 5.5: General Types of Best Management Practices (BMPs)

Type of Behavior	Description
Source Control BMPs	Source control BMPs help keep pollutants from coming in contract with stormwater. They are extremely varied and their selection will normally be tailored to the specific source type.
Low Impact Development (LID) BMPs	LID BMPs are site design practices that minimize runoff and maximize infiltration opportunities for runoff.
Treatment Control BMPs (TCBMPs)	TCBMPs are controls that help remove pollutants from stormwater. They can be used in a variety of applications.
Flow Control BMPs	Flow control BMPs reduce discharges that can have a detrimental effect on receiving waters. Consequently, they are often designed for a higher range of storm sizes than treatment controls. Multiuse facilities can incorporate both flow control and treatment control BMPs.

While there is no single definitive source of BMP information, or classification of types, the CASQA BMP Manuals are recommended resources. Each BMP Manual provides specific, source-based information on a wide range of PGAs and BMP alternatives. These critical resources provide additional guidance on the selection, design, implementation, and maintenance of specific BMP options.

2. **Supporting Behaviors**

Supporting Behaviors include a wide range of potential actions that are distinct from BMP implementation, but that help to form a bridge toward it. Examples include joining a watershed organization, calling a stormwater hotline, conducting employee training, or developing a Stormwater Pollution Prevention Plan. All of these actions are likely to facilitate the implementation of BMPs by target audiences. A number of supporting behaviors are valuable endpoints in their own right, or serve as "bridges" to BMP implementation over time. Examples of supporting behavior types are shown in **Table 5.6**.

Table 5.6: Examples of Supporting Behaviors by General Category

Type of Behavior	Description
Information seeking	Programs often seek to direct target audiences to websites or hotlines as a means of gaining access to additional information. Knowledgeable individuals may often be more likely to avoid polluting behaviors or to implement BMPs. Examples of information-seeking behaviors include: • Hotline requests for information (brochures, event schedules, etc.) • Downloads of materials via websites • Attendance at public events
Pollution reporting	Reporting of potential illicit connections, illegal discharges, and other violations assist Stormwater Management Program staff in identifying potential problems. Examples of reporting behaviors include: • Hotline reporting of illicit discharges • Website reporting of illicit discharges • Staff or agency referrals
Participation and involvement	Stormwater Management Programs often encourage individuals to get involved with the program or in other local efforts. By encouraging a higher level of engagement, it is hoped that increases in BMP implementation will ultimately be achieved. Examples of reporting and participation include: • Participation in creek cleanup events, citizen monitoring, weed abatement, etc. • Involvement in non-governmental organizations (NGOs), community groups, etc. • Attendance at public meetings
Administrative and procedural behaviors	Businesses and organizations often engage in a variety of tasks aimed at fostering or ensuring compliance, and ultimately in bringing about BMP implementation. Examples include: • Development of Stormwater Pollution Prevention Plans (SWPPPs) • Employee training • Discharge monitoring • Self-inspections • Changes to operating procedures • Internal proposal writing and advocacy • Grant writing • MOU and cooperative agreement development • Contract development • Regulation review and comment

Variability of Behaviors

It may sometimes be convenient to approach defined populations (commercial operators, residents, construction site workers, etc.) as homogenous groups of individuals with more or less the same traits. However, variability should be expected in any population, and it's important to account for these differences in the identification and characterization of target audiences. Consider the example illustrated in **Figure 5.3** in which the BMP implementation[1] of individuals is found to be normally distributed[2].

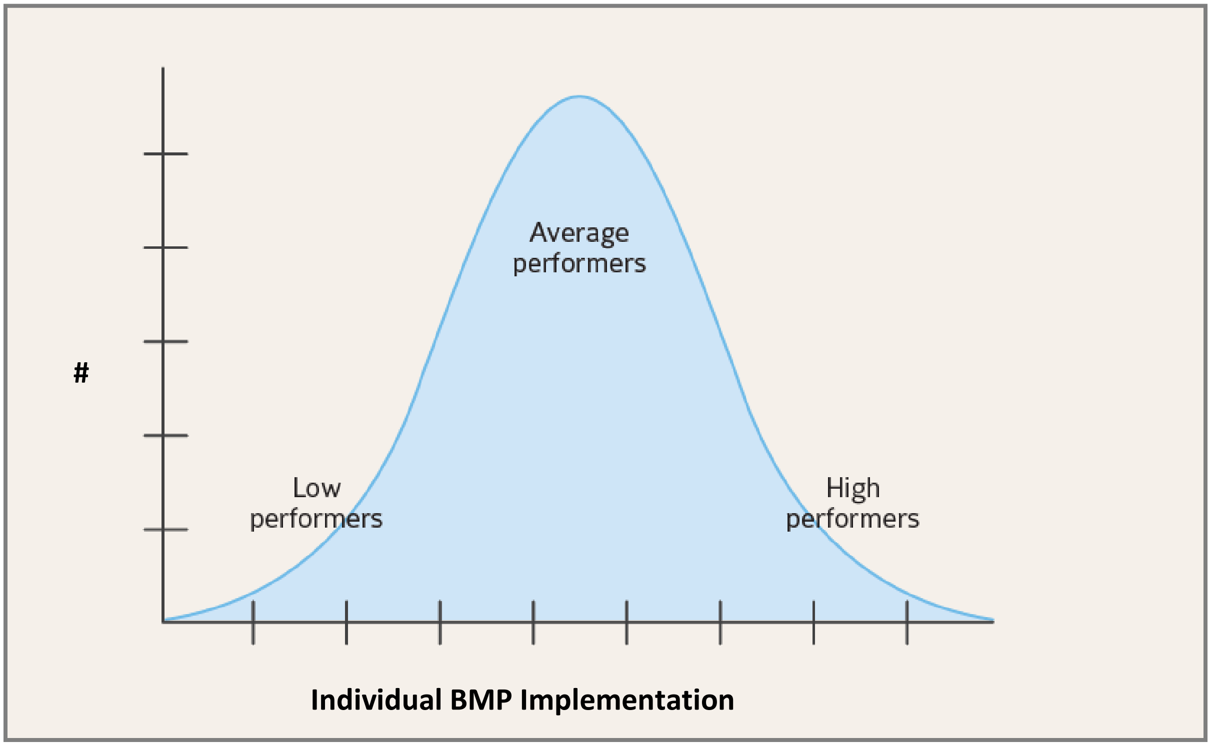


Figure 5.3: Hypothetical Distribution of BMP Implementation by Construction Workers

This distribution could apply to any of the source categories described above, but for illustration it's presumed to represent levels of BMP implementation by construction site workers within a jurisdiction. As shown, a majority of workers will tend to be represented in the center portion of the curve, which has important implications for managers wishing

[1] This is an intentionally vague metric meant only to describe positive behavioral patterns within a population. It could be expressed more specifically as rates, numbers, or magnitude of BMPs implemented, or associated load reductions.
[2] Not all attributes are distributed normally as in this example. For instance, many are positively or negatively skewed, and others are bimodal. Regardless of the actual distribution, this figure is intended to illustrate the differences of individuals within a group.

to maximize BMP implementation across the entire population. Often the smaller numbers of individuals on the tails of the curve tend to act very differently than those in the middle. For example, those on the left might represent the “bad actors” for which higher levels of enforcement are typically needed. Conversely, those on the right are already performing at a high level, and likely do not warrant significant resource commitments. To maximize return on investment, managers benefit from understanding the specific attributes of individuals toward the center of the curve, and how program implementation strategies can best be directed to them. This should not be interpreted to mean that the tails of the curve are unimportant, only that understanding differences between individuals within a population is necessary in the designation of specific target audiences.

Another important aspect of variability is that associated with differences between discrete groups (or sub-populations) within a larger population. **Figure 5.4** illustrates a hypothetical example of a population that has been segmented to reflect differences in the traits of three groups within the larger population.

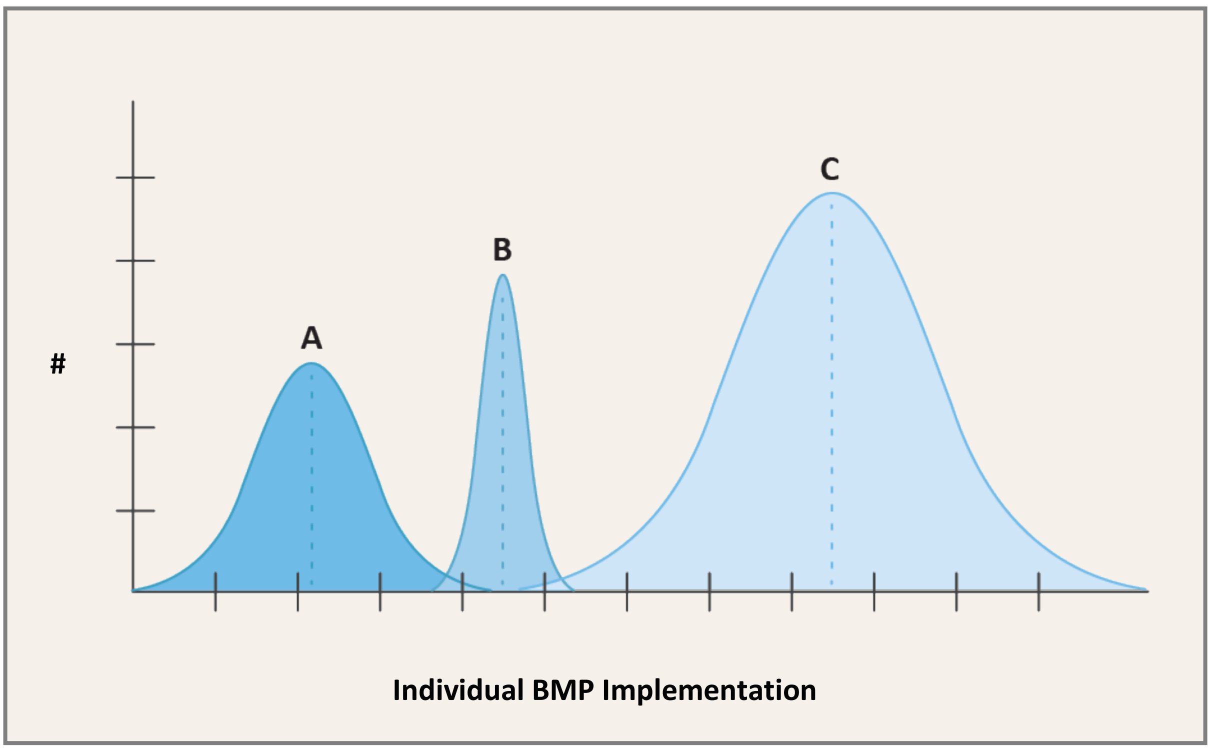


Figure 5.4: Hypothetical Differences in BMP Implementation by Sub-populations of Construction Workers

Assuming the same population of construction site workers represented in **Figure 5.3**, this might be represented as follows:

A = General contractors
B = Skilled workers
C = Laborers

Because the specific involvement and on-site responsibilities of each group varies, their overall contribution to the implementation of BMPs can also be different. This is not intended to imply that one group is outperforming another, just that implementation strategies can be better directed if managers understand these differences. For example, increasing BMP outreach or training for groups A and B might have a lesser return on investment than doing so for group C.

Relationships between Behaviors

Now that a range of behavioral types has been presented, their relationships to each other should also be considered. In particular, managers should consider PGAs and BMPs as coexisting in related groupings that are focused on common target audiences or source contributions. That is, each identified PGA for a particular target audience will have one or more BMP alternatives associated with it[3]. Collectively, these behaviors constitute **PGA-BMP packages**. These packages will be an important organizing principle for much of the remainder of this planning process.

Two examples of PGA-BMP packages are illustrated in **Figure 5.5**. In Example 1, application of currently registered insecticides for ant control is the PGA and three BMP alternatives are identified. It's important to emphasize that the PGA is real, but the BMP alternatives are just conceptual since program activities are not yet in place to facilitate their implementation. The two behavioral types are in opposition, and success will be achieved when the collective benefit of the BMP alternative meets or exceeds the impact of the PGA. This concept will be explored in greater detail when changes are targeted in later planning steps. Of course, this is a simple example, and actual combinations of behaviors can be much more complex. Example 2, centers on vehicle wash water. Together, they illustrate a general approach for grouping related behaviors.

[3] Supporting behaviors can also be included in these packages. However, to avoid complicating the discussion only PGAs and BMPs are discussed here.

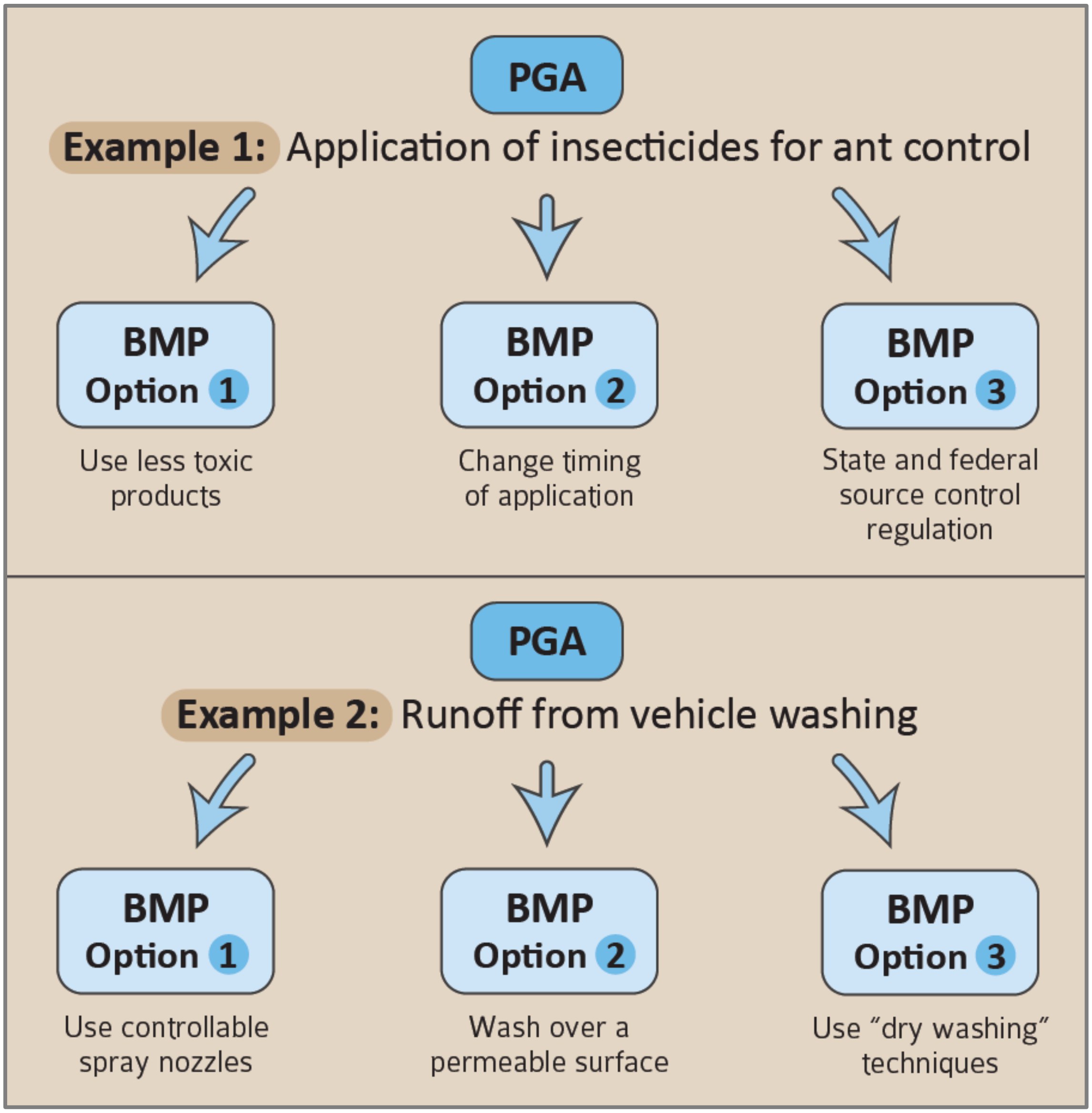


Figure 5.5: Examples of PGA-BMP Packages

Question 3 How are behaviors changing over time?

It's also necessary to consider whether behaviors vary, or are increasing or decreasing, over time. Understanding the temporal patterns of behaviors will later be useful when targeted changes and implementation strategies are explored. Behaviors can vary on a number of timeframes. To illustrate, **Table 5.7** provides a range of examples.

Table 5.7: Examples of How Behaviors Vary Over Different Timeframes

Timeframe	Examples
Hourly (time of day)	• Walking dogs in the morning or evening • Watering lawns early in the morning
Daily (day of week)	• Washing vehicles on weekends • Conducting business operations Monday through Friday
Weekly, monthly, or seasonally (wet/dry)	• Channel maintenance outside of tern nesting season • Doing yard work in the summer

Behavioral patterns can also change over time. Trend estimation can be used to evaluate whether PGAs are decreasing or BMPs increasing as a result of program implementation. The setting in which a particular behavior exists can significantly influence the potential timeframes these changes. For instance, behaviors might change relatively quickly when programs exert direct control (e.g., through building or grading permits), less rapidly in more complex regulatory setting like business compliance, and even slower in the residential sector where program influences are often the weakest. Changes can also be temporary. For example, the exterior use of architectural copper might increase as a result of an increase in the renovation of historic buildings, but later decline with market changes or as other trends emerge.

Question 4 What are the characteristics of target audiences?

In Question 2, managers looked at the behaviors of target audiences. Once it's been determined that a target audience warrants additional consideration (i.e., its behaviors are considered to contribute to priority source loadings), it's helpful to consider other applicable attributes. This will be useful in developing implementation strategies because common attributes can be helpful in understanding why a group behaves in certain ways, or what factors might be relevant in changing their behaviors. As such these characteristics can be instrumental in shaping the way a target audience is approached. **Table 5.8** presents a number of potential characteristics that might be considered for various target audiences.

Table 5.8: Examples of Potential Target Audience Characteristics

Type of Characteristic
Social and Demographic Characteristics • Population (by area, density, distribution, etc.) • Race/ethnicity • Language • Gender • Age (median, % seniors, % children, etc.) • Educational attainment (<high school, high school, bachelor's, graduate)
Economic Characteristics • Income (median, per capita, % below poverty level, • Employment (unemployment rate; job types, classifications, and responsibilities) • Communities of concern • Household income • Means of transportation • Income spent on transportation
Housing Characteristics • Housing (ownership rates, renters, etc.) • Homeless rate • % spending > 30% of gross annual income on housing
Other Specific Characteristics (partial list for illustration) • Business practices • Pet ownership • Organization and club membership • Media and communication usage patterns (internet, television, etc.) • Other

In general, a wide range of data and information are normally available. Where available, managers are encouraged to utilize standardized population and demographic data (e.g., through the U.S. Census Bureau, housing and transportation agencies, and associations of government). Standardized data and information on other characteristics such as those listed under item 4 may not be easily obtainable.

Review Checklist

Step 3-A Task 1
Evaluating Target Audiences

Apply this task very broadly across all target audiences potentially associated with priority sources. The purpose is to provide a "snapshot" of what is currently known about these audiences.

- ✓ **Compile existing data, information, and results applicable to known or potential target audiences. Consider the following questions:**

  Question 1: Which target audiences are associated with priority source contributions?

  Question 2: What are the behavioral patterns of target audiences?

  Question 3: How are behaviors changing over time?

  Question 4: What are the characteristics of target audiences?

- ✓ **Consolidate results into one or more summary lists of existing conditions. Categorize results as determined appropriate (by audience, behaviors, other characteristics, etc.).**
- ✓ **Compile supporting documentation for listed conditions.**
- ✓ **Select the audiences in the summary list(s) that will be further evaluated in Task 2. Consider "back-up" lists for future evaluation as necessary.**
- ✓ **Document the critical data and information gaps identified during Task 1 completion.**

NOTES

Figure 5.6: Review Checklist for Evaluating Target Audiences

Task 2 Defining Behavioral Problems

The objective of this task is to determine which of the behaviors identified above actually constitute problem conditions, i.e., they contribute to one or more priority source contributions. Two key questions guide the evaluation of behavioral problems.

Step 3-A Task 2 Key Questions
Defining Behavioral Problems

Inputs	Key Questions	Outputs
Target Audience Behaviors and Characteristics	**Question 1**: Is the behavior causally linked to a known or suspected source contribution? **Question 2**: Is there independent evidence for designating the behavior as a problem?	**Problem Behaviors**

Question 1 Is the behavior causally linked to a known or suspected source contribution?

When a source contribution is known or suspected, behavioral problems are implicated as potentially causing or contributing to it. PGAs are normally considered to represent problem conditions if their magnitude and prevalence is sufficient to cause a significant source loading. BMPs and supporting behaviors can also be considered problems if they are absent or existing levels of implementation are low. A critical consideration is the degree to which existing data and information support the establishment of linkages of either type of behavior to specific source contributions.

In some cases, the evidence can be direct and conclusive (e.g., runoff to the street can be observed to result from people overwatering their lawns). In other cases, linkages between behaviors and discharges are less conclusive. Where they're suspected, managers should focus on confirming or strengthening them over time. Those that can be confirmed may be implicated as significant problem conditions. In practice, the investigation of behaviors does not always result in evidence of causality, so other lines of evidence should be considered.

Question 2 Is there independent evidence for designating the behavior as a problem?

Behaviors may sometimes also be classified as PGAs based solely on their general characteristics. This makes sense since a behavior that can be observed to mobilize or transport pollutants or flows will intuitively have some "pollution potential". However, in many cases, observed problem behaviors will not result in higher outcome level problems. Common examples include the outdoor application of pesticides and fertilizers. Even though observations of runoff from residential yards may appear to implicate these substances as problematic, monitoring results may not show impacts to local water bodies. While this may suggest to some parties that the discharges are not problematic, other managers will look at this differently and conclude that any amount of runoff from these activities is contributing to a problem, measurable or not. A similar example would be the application of pesticides, which is also often concluded to be problematic even in the absence of measurable water quality impacts. Both examples underscore the importance of discretion in deciding which behaviors represent problem conditions.

Review Checklist

Step 3-A Task 2

Defining Behavioral Problems

Apply this task individually to each behavior identified in Task 1 for further evaluation. The purpose of this task is to determine which of these behaviors should be designated as problems.

- ✓ **For each identified condition, consider the following questions:**

  Question 1: Is the behavior causally linked to a known or suspected source contribution?

  Question 2: Is there independent evidence for designating the behavior as a problem?

- ✓ **Document known or suspected problem behaviors.**
- ✓ **Consolidate results into one or more summary lists. Categorize results as determined appropriate (by target audience, PGAs, BMPs, etc.).**
- ✓ **Compile supporting documentation for listed conditions.**
- ✓ **Document the critical data and information gaps identified during Task 2 completion.**

NOTES

Figure 5.7: Review Checklist for Defining Behavioral Problems

Task 3 Prioritizing Behavioral Problems

Given the wide range of problem behaviors likely to be identified for any specific target audience, prioritization will help to ensure that managers' efforts stay focused on those considered to be most important. In establishing priorities, a variety of potential factors will need to be considered. The key questions below will help to guide managers through a general prioritization process, but they may be fleshed out or modified as experience is gained and in response to individual circumstances. Note that this process follows the sustainability approach described in **Section 3.0**.

Prioritization follows a two-step process (**Figure 5.8**). Each problem is first reviewed to determine its priority rating. Ratings are then considered together to determine their relative priority ranking. Managers may already have other preferred approaches than those described, and should choose those that work best for them.

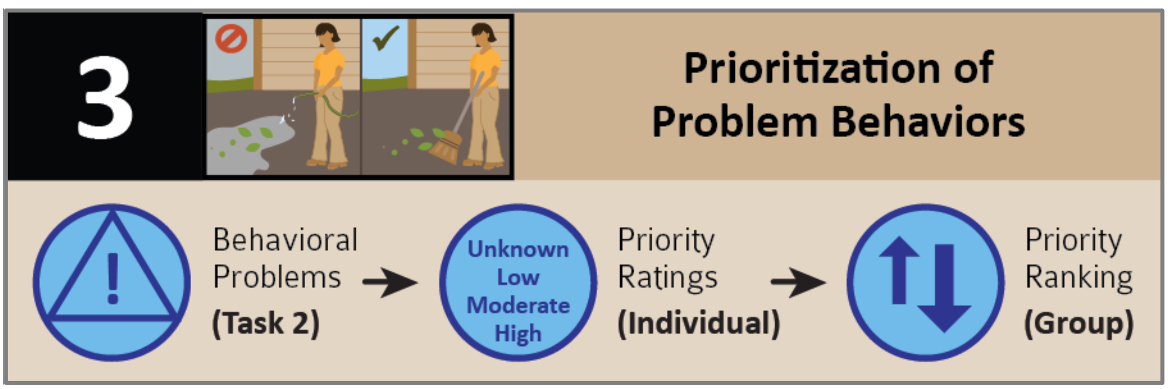


Figure 5.8: General Process for Prioritizing Problem Behaviors

The key questions below should be applied individually to each **Task 1** problem behavior identified in the order presented. They can also be applied to the prioritization of BMP alternatives within a defined PGA-BMP package. In either instance, this will result in priority designations for each problem behavior. Once these designations have been made individually, they can be considered together to determine which of them will be targeted for change in **Step 3-B**.

Step 3-A Task 3 Key Questions
Prioritizing Behavioral Problems

Inputs	Key Questions	Outputs
Identified Problem Behaviors	**Question 1:** What is the priority rating of each behavior? **Question 2:** What is the relative importance of each behavior?	**Priority Behavioral Problems**

Question 1 What is the individual priority rating of each behavior?

Establishment of priority ratings establishes values for the priority of each identified behavior. This is approached through the three review tiers introduced in **Section 3.3**. Given the qualitative nature of the exercise, ratings for all factors should generally be kept as simple as possible.

Tier 1 Regulatory Screening

Tier 1 is a simple screening step. Most target audience behaviors aren't explicitly addressed in permits. However, if a behavior is legally required or prohibited (e.g., overwatering), or is otherwise meaningfully affected by legal or regulatory requirements, there may be little discretion in determining its priority.

Tier 2 Technical Review

The priority rating of a behavior should reflect its significance, certainty, and controllability. **Significance** refers to the nature, magnitude, and prevalence of the behavior. Each of these attributes will already have been considered in Task 1, so this is primarily a review and consideration of those results. Ideally the litmus test for significance is an understanding of how and to what degree the behavior influences priority source contributions. In practice, it can be difficult to establish these linkages. In designating an overall value for significance, managers will need to decide how to weigh each of the three contributing criteria.

Certainty describes the confidence that managers have in their understanding of the existence and attributes of the behavior. Certainty will tend to be positively correlated with priority (i.e., the higher the certainty, the higher the priority). Behavioral assessments that are based on simple observations or anecdotal information are likely to be somewhat uncertain. Like other outcomes, certainty increases with data support (e.g., through surveys) and statistical analysis.

Controllability is the potential for a program to control or modify the behavior. Low controllability behaviors do not tend to be priorities for resource commitments. In general, target audience behaviors are difficult to modify. Controllability is generally higher for highly regulated populations such as construction and development audiences, or for municipal staff. Commercial and industrial audiences can also be difficult to control where they are not subject to inspection and enforcement. Likewise, residential audiences, which are primarily addressed through education and incentive programs, can be the most difficult to control.

Tier 3 Sustainability Review

The Sustainability Review brings in two additional sets of considerations.

Economic Impacts are essential considerations because every problem and every proposed solution has one or more costs associated with it. The costs of continuing a PGA, and those of the BMPs that are potentially needed to reduce or eliminate it, can all be relevant. Costs may be borne by the target audience, the program, or other parties. At this point, considerations of program costs can often be premature since program implementation strategies may not have been developed.

Costs should consider more than just magnitude. Cost-effectiveness and return-on-investment (ROI) are also relevant. The most efficient or effective options may not be the least expensive ones.

Social Impacts are those related to the target audience, society at large, or other specific segments within it. Some behaviors may be determined to have social impacts that are publicly acceptable. Behavioral changes that are drastically different from the current social norm may be publicly criticized, rejected, and difficult for the municipality to bring about. For example, fireworks are displayed over a waterbody as part of an annual event. An option would be to prohibit the fireworks, but social considerations could make it very unpopular to do so. Without very strong evidence of the need for a ban, the leadership of the municipality may be very uncomfortable banning this activity.

Managers should also keep in mind that neither of these ratings reflects a particular direction of impact. Economic and social ratings can be either positive or negative. It’s also quite possible that multiple economic or social factors will be identified. Because a single rating is needed for each, managers will need to use discretion in evaluating the net impact of those factors.

Assignment of Priority Ratings

Considering each of factors described above, an **individual priority rating** should be assigned to each behavior. As described in **Section 3.3**, the particular methodologies used to weigh contributing criteria are left to the discretion of managers. However, complex weighting schemes are generally discouraged because of the qualitative nature of the exercise. Each of these ratings is assigned individually, and has nothing to do with the respective priorities of other behaviors.

Table 5.9 illustrates several examples of how priority ratings might be assigned to individual behaviors. While a specific set of rating values is utilized for illustration, managers should feel comfortable substituting any designations they consider appropriate (0-1-2-3, A-B-C-D, etc.).

These examples assume an equal weighting of each of the contributing factors in each part, but the actual weighting should be determined by the manager conducting the exercise. It's possible to prioritize behaviors using quantitative scoring methods. But in most cases, qualitative ratings are appropriate and reasonable.

These examples are purely qualitative in that each of the individual designations is more or less lined up, with an overall priority rating being estimated by "eyeballing" the collective weight of the results. It should be emphasized that each example lends itself to differing interpretations. The best results are likely to be obtained when all available data are considered, and when managers have a high degree of familiarity with each of the individual scoring factors. Prioritization processes are always subjective and managers should avoid the use of schemes that assume a level of precision that is unwarranted or that are too literal in the interpretation of results.

Table 5.9: Examples[4] of the Assignment of Priority Ratings to Behavioral Conditions (PGAs)

Problem Behaviors	Tier 1: Regulatory Screening	Tier 2: Technical Rating				Tier 3: Sustainability Ratings			Overall Priority Rating
		Significance	*Certainty*	*Controllability*	*Overall*	*Economic Factors*	*Social Factors*	*Overall*	
Overwatering of residential lawns	**Unknown**	High	Moderate	Moderate	**High**	Moderate	High	**Mod-High**	**High-Mod**
Sidewalk rinsing	**Unknown**	Insignificant	Uncertain	Low	**Low**	Low	Moderate	**Low-Mod**	**Moderate**
Floor, mat, and surface cleaning	**Unknown**	Low	Low	Low	**Low**	Unknown	Moderate	**Moderate**	**Low**
Pesticide application	**Low**	Mod	Low	Low	**Low**	High	Low	**High**	**Low**

[4] These examples are hypothetical and for illustration only. They are not intended to imply a particular priority for any of the behaviors listed.

Question 2 What is the relative importance of each behavior?

Problem behaviors must now be evaluated together to determine their relative importance. As this stage, a variety of potential behavioral priorities are likely to be generated. In determining their relative importance, two types of scenarios may be considered. Although many-to-one relationships between source contributions and behaviors are normally expected, these can take different forms. It will often be the case that multiple behaviors (either PGAs or BMPs) contribute to an identified source contribution. However, a single behavior (e.g., overwatering) can also contribute to multiple source contributions (e.g., discharges of flow from several outfalls). Both types of scenarios are important, and the approaches described here can be applied to either.

The final output of **Task 3** will be a ranked list of priority behaviors corresponding to priority source contributions. Problem behaviors can either be put into a ranked order or be grouped by their priority ratings. Establishing ranked orders consists of lining up the behaviors under consideration from highest priority to lowest, with the higher priorities normally constituting the greater management priorities. As illustrated in **Figure 5.7**, behavioral problems will sometimes have "tie scores". Rather than further differentiating between them, grouped rankings may be considered. Depending on the degree of information available, "sub-rankings might also be developed within each group. As previously emphasized, this is a qualitative exercise, and rating and ranking systems cannot replace the role of judgment in evaluating results.

↑ Increasing Priority ↑	RANKED ORDER EXAMPLE	GROUPED RANKING EXAMPLE
	1. Overwatering of residential lawns 2. Sidewalk rinsing 3. Floor, mat, and surface cleaning 4. Pesticide application	**GROUP A (High-Moderate)** • Overwatering of residential lawns **GROUP B (Moderate)** • Sidewalk rinsing **GROUP C (Low)** • Floor, mat, and surface cleaning • Pesticide application

Figure 5.9: Potential Options for Ranking Problem Behaviors

Figure 5.10 provides a Review Checklist to guide Task 3 completion. Significant data and information gaps are likely to be associated with behavioral outcomes. It's important to document and consider them in the development of future data collection strategies.

Review Checklist

Step 3-A Task 3
Prioritizing Behavioral Problems

Apply this task individually to all problem conditions identified in Task 2. Its purpose is to assess and rank the priorities of problem conditions.

✓ For each identified behavioral problem, consider the following questions:

Question 1: What is the priority rating of each problem behavior?

☐ **Tier 1: Regulatory Screening** **REGULATORY RATING ________**

- ✓ Identify regulatory requirements and constraints affecting priority.
- ✓ Based on their collective impact, assign a Tier 1 rating.
- ✓ Note the overall direction of influence of the rating (requirement or constraint).
- ✓ Should an Overall Priority Rating be assigned based solely on regulatory criteria? If yes, stop and document. If no, continue to Tier 2 Review.

☐ **Tier 2: Technical Review** **TECHNICAL RATING ________**

- ✓ Evaluate the significance, certainty, and controllability of the behavior. Establish individual weightings as appropriate for each of the three factors.
- ✓ Based on review of the above factors, assign a Tier 2 Rating.
- ✓ Should the problem be eliminated from further consideration or assigned a "low" Overall Priority Rating based solely on technical criteria? If yes, stop and document. If no, continue to Tier 3 Review.

☐ **Tier 3: Sustainability Review** **SUSTAINABILITY RATING(S) ________**

- ✓ Identify economic factors and social factors affecting the behavior.
- ✓ Assign a Tier 3 Rating for economic and social factors individually or collectively.

☐ **Overall Priority Rating** **OVERALL PRIORITY RATING ________**

Collectively consider Regulatory, Technical, and Sustainability results to assign an Overall Priority Rating for each behavior. Assign individual weightings for each of the factors considered. Economic and Social factors may be counted individually or together.

Question 2: What is the relative importance of each receiving water problem?

☐ **Rank individual priority ratings for further consideration in Step B.**

✓ Document the critical data and information gaps identified during Task 3 completion.

Figure 5.10: Review Checklist for Prioritizing Behavioral Problems

Step 3 - B Targeted Behavioral Changes

Step 3-B addresses the establishment of measurable targets for behavioral change. Targets for change should be considered at least for the highest priority behaviors identified above. As shown in **Figure 5.11**, targeting consists of three tasks.

Figure 5.11: Targeted Behavioral Changes (Step 3-B)

The identification of specific targets for behavioral change that will constitute success is a critical step in the development of management strategies. Interim targets will also help to define an incremental pathway toward the achievement of longer-range goals. Once a pathway for achieving changes is projected, the metrics and methods needed to document and support their evaluation can be established.

Three sets of inputs should be considered. The starting point will be the list of **Priority Behavioral Problems** identified in **Step 3-A Task 3**. For each identified priority, one or more specific targets for change should be considered. Outcome Level 4 Results will be reviewed, in particular, priority pollutant and flow contributions. Finally, managers should review all applicable **Target Audience Data and Information** gathered in **Step 3-A Task 1**.

Task 1 Identifying end-state behavioral targets

This step identifies approaches to establishing end-state behavioral targets. Two key questions are used to guide this process.

Step 3-B Task 1 Key Questions
Identifying End-state Behavioral Targets

Inputs	Key Questions	Outputs
Priority Behavioral Problems	**Question 1**: What is the end-state for the behavior? **Question 2**: When will end-state behaviors be achieved?	**End-state Behavioral Targets**

Question 1 What is the end-state for each targeted behavior?

The selection of behaviors for targeting should initially include all of the PGAs and BMPs in each identified PGA-BMP package; PGAs will be targeted for reductions and BMPs for increases. Targeting should consider the relative impact of each behavior on desired source reductions and the potential of achieving desired changes. At this point, some behaviors may be determined to be lower priorities than initially thought.

Determining how much change is needed is one of the most challenging parts of the targeting process since multiple behaviors tend to act on the same source contributions, and the respective influence of each is not usually well-known. Conceptually, there are a few obvious starting points. The first of these is the total elimination of a PGA. Targeting to eliminate a PGA is tempting because it provides a clear endpoint. However, while conceptually simple, elimination of PGAs is not usually realistic. It generally makes more sense to establish realistic measurable targets that can be evaluated and modified over time.

The establishment of targets should consider the review factors and general conceptual approaches described below.

Review Factors

As shown in **Figure 5.12**, the same general factors introduced above during problem prioritization are applicable to the establishment of behavioral targets.

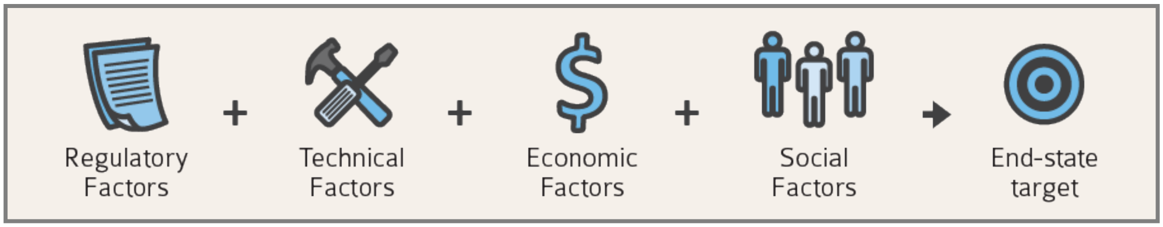


Figure 5.12: Factors Relevant to Setting Targets for MS4 Changes

"Draft" targets can initially be established through a consideration of the regulatory and technical factors introduced above in Task 3-A-3, and those results further reviewed and refined as necessary in the context of sustainability considerations. This process may need to be repeated multiple times as additional data and information become available.

In determining the magnitude of targeted changes, the following options should be considered.

General Approaches to Establishing End-state Behavioral Targets

Approaches to targeting may include any of the following, individually or in combination.

Setting Targets to Comply with Regulatory Requirements

Setting targets to regulatory requirements, particularly those established in permits, should always be considered up front. Most permits do not set explicit requirements for behavioral change in target audiences, but these should be adhered to if applicable.

Setting Targets to Achieve Specific Level 4 Changes

This should be the preferred approach when measurable targets have been defined for the higher outcome level changes, and their relationship to the behavior is known. Since the magnitude of source reductions is assumed to be a function of the magnitude of behavioral changes, an increase or decrease in one should cause a corresponding change in the other. Ideally both endpoints are known and quantifiable. Where they are not, relationships between them can still be explored "experimentally" as described below.

Setting Targets to Resource Availability

Resource availability must often be considered because programs don't always have the staffing, budget, or other resources needed to pursue behavioral targets established through other approaches. Resource availability presents real world constraints that must be considered, although it's also important to remember that targets which are too low may not be effective. Rather than under-targeting because of resource limitations, it may make more sense to defer targeting some behavioral changes until additional resources can be obtained, or to divert those existing resources to other priority behaviors.

Setting Targets to Learn and Adapt

This approach involves establishing targets to explore the potential for affecting behavioral changes. Because these conditions are sequentially linked both to level 4 and 2 conditions, managers can also benefit from exploring relationships to these higher and lower level outcomes.

One way of approaching this is through the establishment of **stretch targets**. For example, if 50% of a target audience currently implements a behavior, 60% could be targeted over a defined period. Existing facilitation activities could then be “dialed up” and results periodically evaluated to see if behavioral changes are resulting. An advantage to stretch targeting is that it allows efficiencies to be evaluated as activities are incrementally increased. **Experimental targets** are similar to stretch targets, but are instead intended to explore and test assumptions or hypotheses about relationships between target audience behaviors and other outcomes. In the absence of specific information on the relationship of facilitation activities to behavioral change, managers will often need to take a trial-and-error approach. Specific levels of implementation can be targeted and tracked along with ongoing assessment of source load reductions. By exploring potential causal relationships, managers can set a course for “managing to learn”.

Question 2   When will end-state behaviors be achieved?

Depending on the types of changes that are targeted, significant periods of time may be needed. In instances where programs exert a high degree of direct control (e.g., through building or grading permits), changes can occur very quickly, but in most instances managers should realistically expect that multiple years, and in some cases decades, may be needed.

Task 2 Establishing interim behavioral targets

This step identifies approaches to establishing the interim targets to assist in evaluating progress towards achieving end-state behavioral targets. Two key questions are used to guide this process.

Step 3-B Task 2 Key Questions
Establishing Interim Behavioral Targets

Inputs	Key Questions	Outputs
End-state Behavioral Targets	**Question 1**: What interim targets are needed to evaluate progress toward the end-state behavior? **Question 2**: When will interim targets be achieved?	**Interim Targets**

Question 1 What interim targets are needed to evaluate progress toward the end-state behavior?

Change is not linear, so managers should be realistic about how quickly they can expect behaviors to change. Consider a population of industrial operators with 65% overall compliance rate (e.g., no BMP violations observed during 65% of inspections). If a 5-year goal of bringing this rate to 90% is established, managers wouldn't expect 1/5th of the goal to be achieved each year. Realistically, allowances need to be made for the time it takes to "ramp up," refine, and fully implement a program. Likewise, there will be a point at which maximum gains should be expected, and possibly diminishing returns beyond after that. Interim targets establish milestones along the way necessary to realistically anticipate critical events in the implementation curve, and to make adjustments in response to results. They allow progress to be measured and strategies to be adjusted along the way. They're critical to adaptive management.

Question 2 When will interim targets be achieved?

Timeframes for interim targets should reflect the initial schedule set for achieving the end-state condition, the need for specific feedback along the way, and the ability to measure change over interim periods. Interim targets should not be set so aggressively that it will be difficult to obtain useful feedback.

Task 3 Identifying data requirements

Now that targets for behavioral change have been identified, it's necessary to identify how they will be measured, what data are needed to allow measurement, and how these data will be collected and analyzed. Planning is not complete unless managers are fully prepared to obtain and evaluate the data needed to assess each targeted change. Each of the questions below should be addressed for every targeted outcome addressed in Step 3-B.

Question 1 What metrics will be used?

Behavioral changes should be expressed in unambiguous terms. This should include a specific formulation of the outcome statement, the assignment of units of measure or assessment, and units of time. **Section 7.3** provides additional detail on the establishment of metrics.

Question 2 What data collection methods will be used?

It's also essential that managers identify how data will be collected for each targeted receiving water outcome so that it can be tracked and assessed. **Section 7.4** provides additional detail on potential data collections options.

Question 3 What data analysis methods will be used?

The last consideration for any targeted behavioral change is how the data will be evaluated. The choice of analytical method can dictate what specific metrics should be used, how the data should be collected, and the quality of the result. **Section 7.5** provides additional discussion of data analysis options.

Where the establishment of data requirements for behavioral change cannot be satisfactorily addressed up front (e.g., there's no available option for collecting the desired data), this may need to be documented as a knowledge and data gap (**Step 6-C**).

Figure 5.13 provides a Review Checklist to guide Step 3-B completion.

Review Checklist

Step 3-B Tasks 1, 2, and 3

Targeted Behavioral Changes

Apply this task individually to all problem behaviors identified in Task 2. Its purpose is to identify specific targets for behavioral change.

✓ **End-state Targets (Task 1)**
Consider the following questions:

Question 1: What is the end-state for the behavior?
Question 2: When should the end-state condition be achieved?

✓ **Interim Targets (Task 2)**
Consider the following questions:

Question 1: What interim targets are needed to evaluate progress toward the end-state behavior?
Question 2: When will interim targets be achieved?

✓ **Data Requirements (Task 3)**
Consider the following questions:

Question 1: What metrics will be used?
Question 2: What data collection methods will be used?
Question 3: What data analysis methods will be used?

✓ **For each priority behavioral problem, document interim and end-state targets, and the data requirements necessary to track and evaluate them.**

✓ **Compile one or more lists of targeted behavioral changes and supporting documentation for listed conditions.**

✓ **If a priority behavioral change is not or cannot be targeted, document the reason.**

✓ **Document all Step B data and information gaps.**

NOTES

Figure 5.13: Review Checklist for Targeting Behavioral Changes

Step 3 - C Documenting Knowledge and Data Gaps

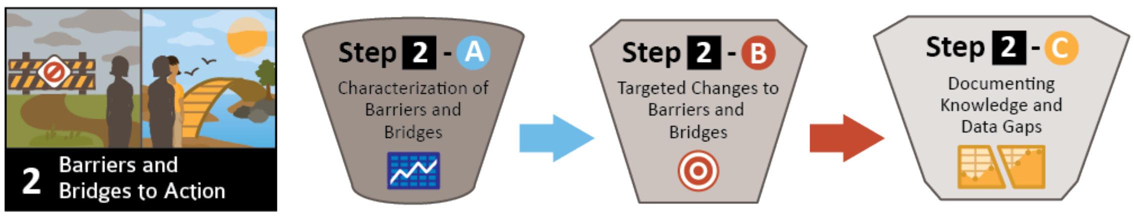
The identification of knowledge and data gaps should be ongoing throughout the entire Level 3 planning process. At its conclusion, managers should have developed a list of gaps that can be incorporated into a Monitoring and Assessment Strategy. **Section 7.0** provides additional guidance on assessment tools and strategies to support the development of these strategies. Because an existing baseline of data and information does not exist for many target audience attributes, Level 3 knowledge and data gaps are likely to be significant. Critical gaps must be addressed to ensure that they are resolved over time. **Table 5.10** provides examples of general areas of inquiry where Level 3 knowledge and data gaps are likely to be encountered. These are intended to provide a framework for identifying actual knowledge and data gaps, which will be much more specific than those listed here.

Table 5.10: Potential Areas of Behavioral Knowledge and Data Gaps

- ✓ Understanding of behavioral patterns (nature, magnitude, prevalence, distribution, variability, and trends)
- ✓ Availability and adequacy of behavioral data
- ✓ Knowledge of how regulatory requirements and constraints affect behavior
- ✓ Knowledge of how economic factors affect behavior
- ✓ Knowledge of how social factors affect behavior
- ✓ Methodologies, criteria, and data support for conducting problem identification
- ✓ Methodologies, criteria, and data support for prioritization

5.3 Outcome Level 2: Barriers and Bridges to Action

A number of behaviors associated with priority target audiences have now been identified, and targets set for the changes to be pursued in them. Targeted behavioral changes were established within the context of the **PGA-BMP packages** identified in Level 3 above. The purpose of Level 2 planning is to identify the factors that influence these behaviors now, or that will influence the changes that will be sought in them. This will later serve as a basis for the development of strategies to motivate, empower, or compel target audiences to reduce or eliminate the use of PGAs and increase the use of BMPs. As shown here, Level 2 planning is a three-step process.



In **Step 2-A** managers will identify, explore, and prioritize, the factors influencing priority target audience behaviors. This will initially include looking at a wide range of potential **influencing factors**, but an important focus of this step will be to determine how each of these might represent "**barriers**" or "**bridges**" to practices that are protective of water quality. **Step 2-B** will focus on targeting changes in influencing factors that favor the implementation of BMPs over PGAs. Finally, **Step 3-C** will look at the knowledge and data gaps discovered along the way, so that future data collection initiatives can be directed toward resolving them.

Step 2 - A Characterization of Barriers and Bridges

A number of factors can affect managers' ability to achieve desired behavioral outcomes. As shown in **Figure 5.14**, their characterization entails three distinct tasks. Influencing factors are initially considered broadly with an eye toward understanding their general characteristics. The focus is then narrowed to factors representing problem conditions, i.e., favoring the implementation of PGAs over BMPs. Prioritization allows managers to focus on those barriers that will be targeted in the development of implementation strategies.

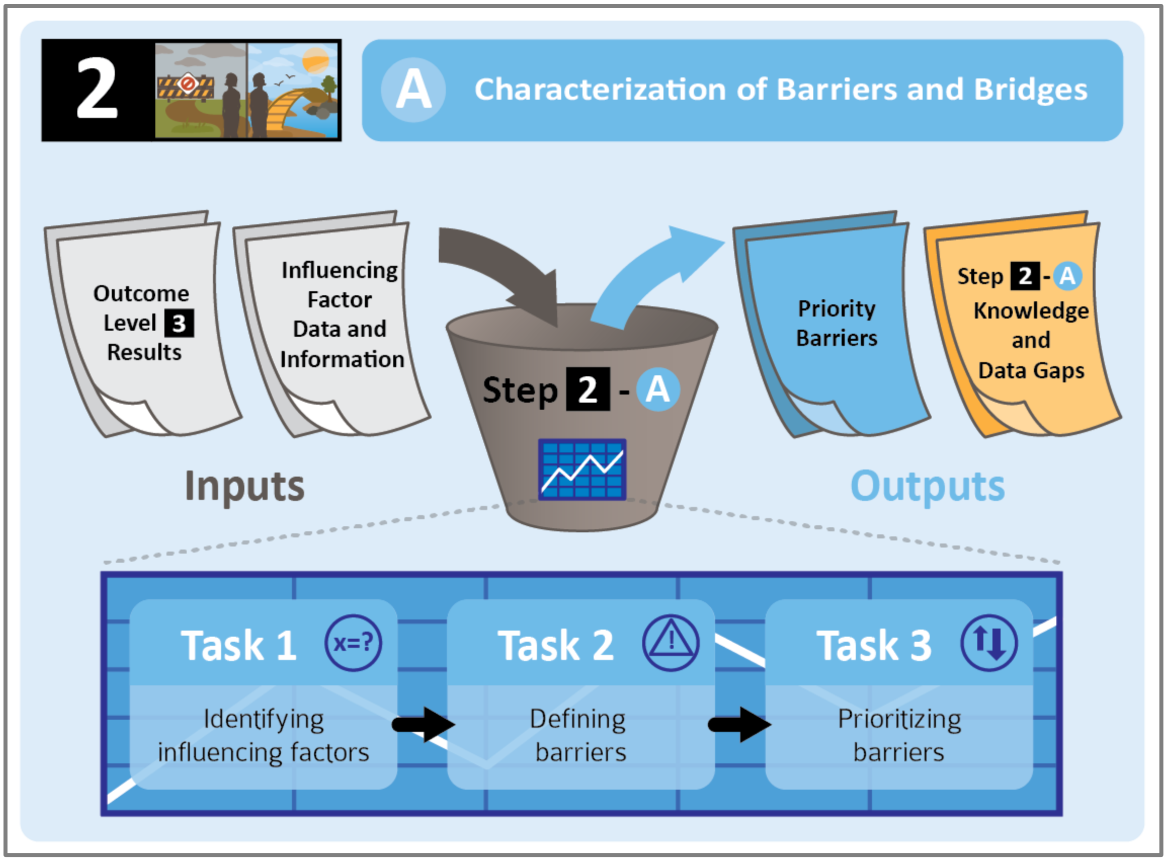


Figure 5.14: Characterization of Barriers (Step 2-A)

Table 5.11 identifies a number of typical data and information inputs that may be useful in Level 2 strategic planning. Level 3 planning results should always be a first consideration since information already obtained on target audiences can be particularly useful. For example, demographics and other target audience characteristics might help to identify influences unique to specific populations. Likewise, socioeconomic data, possibly in combination with BMP implementation costs, could assist in identifying potential economic barriers. Many other sources of data and information can also be relevant. Most programs have been collecting data such as inspection results, surveys and tests, and hotline inquiries for years or decades. To varying degrees, all of these sources are potentially relevant.

Table 5.11: Potential Inputs for Level 2 Planning

A. Level 3 Results (from Section 5.2)
☑ Priority target audiences (residents, employees, contractors, etc.)
☑ Priority behaviors (BMPs, PGAs, supporting behaviors, etc.)
☑ Target audience characteristics (population, socioeconomic, housing, etc.)
☑ BMP implementation costs
☑ Knowledge and data gaps
B. Other Miscellaneous Data and Information Sources (examples only)
☑ Existing programs (annual reports, electronic and hard copy records and documentation, etc.)
☑ Interviews, surveys, tests, and quizzes
☑ Facility or site inspections
☑ Complaint investigations
☑ Pollution reports and referrals (hotline, employee, contractor, etc.)
☑ Third party data (submission of compliance data, monitoring data, maintenance records, etc.)
☑ Population, demographic data, etc. (census bureau, associations of governments, etc.)
☑ Special investigations (community-based social marketing studies, etc.)
☑ Research, literature, and technical reports (CASQA BMP Manuals, surveys, etc.)
☑ Other (TBD as needed)

Task 1 Identifying Influencing Factors

In Task 1 managers will consider a range of factors with the potential for influencing any of the behaviors in the priority **PGA-BMP packages** identified during Level 3 planning[5]. At this point all potential influences should be of interest. Available data and information will initially be reviewed to address the two key questions below for each behavior under consideration. This can initially seem somewhat daunting, but it should be emphasized that the process does not have to be repeated in its entirety for every identified influencing factor since they will often be similar or the same for multiple target audience behaviors.

[5] Supporting behaviors can also be addressed as part of this task, but are not discussed further here because the primary focus of this section is on the PGAs and BMPs associated with primary target audiences.

Step 2-A Task 1 Key Questions
Identifying Influencing Factors

Inputs	Key Questions	Outputs
Available Data, Information, and Results	**Question 1:** What factors influence priority target audience behaviors? **Question 2:** How are influencing factors changing over time?	**Identification of Influencing Factors**

Question 1 What factors influence priority target audience behaviors?

An **influencing factor** is anything that affects the behaviors of an individual or group. Many types of factors can influence the PGAs[6] and BMPs constituting the priority PGA-BMP packages introduced above. To illustrate, **Figure 5.15** shows a hypothetical example with monthly insecticide spraying around the home as the PGA and three potential BMP options. As shown, a number of factors can influence any of the behaviors, and some of these can apply across more than one of the behaviors.

These factors and the parameters that shape them are explored below. This will help managers to validate the behavioral priorities initially established in Level 3 planning, and to set the stage for later targeting solutions.

Managers will sometimes already know what the factors influencing a behavior of interest are. This process is not intended to supplant existing knowledge or judgment. Its purpose is to provide a means of thoroughly and systematically exploring a range of typical influencing factors. Managers should use whatever approaches work best for them.

---

[6] Multiple PGAs are possible, but it's expected that most PGA-BMP packages will most commonly consist of a single PGA and one or more BMP alternatives.

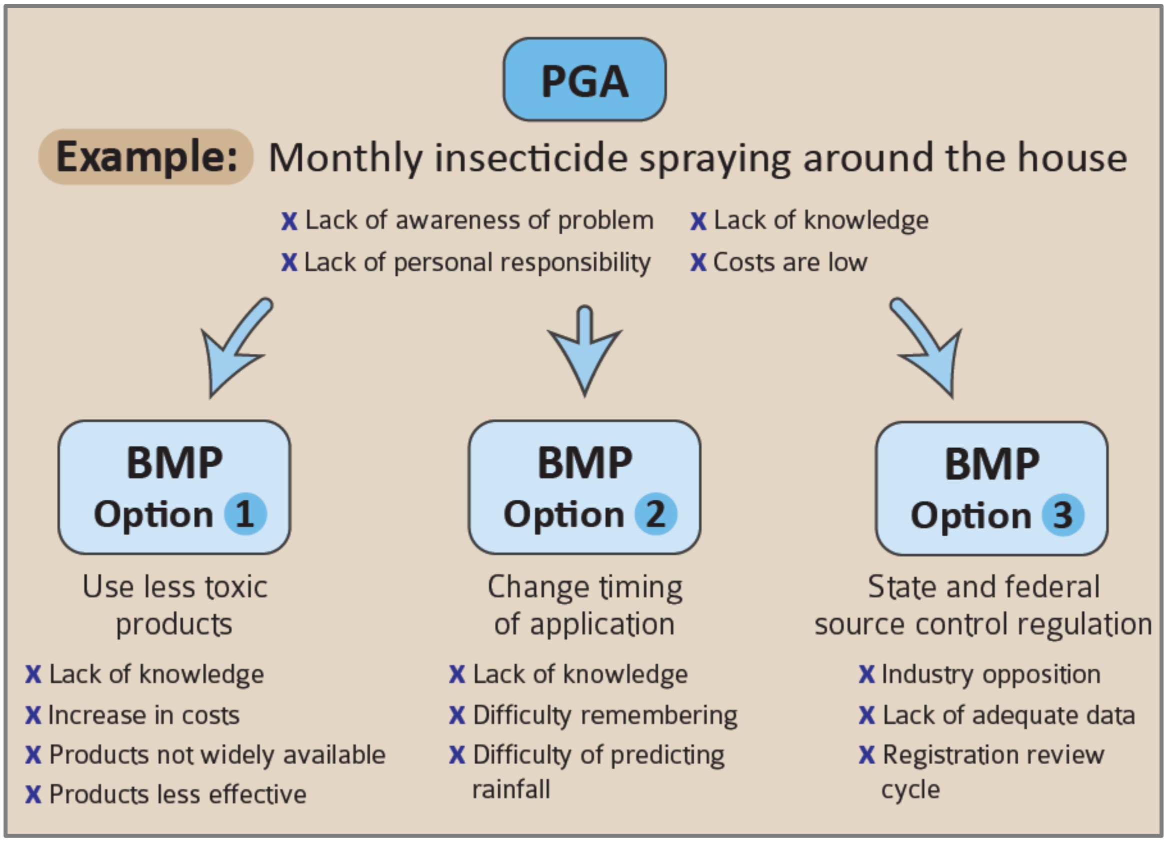


Figure 5.15: Example of Influencing Factors Associated with a PGA-BMP Package

Types of Influencing Factors

Influencing factors can be either of two general types, personal or external. **Personal factors** are attributes of individuals within a defined population. Their importance lies in the fact that there is always an element of personal choice in engaging in any behavior. Personal factors directly influence people's motivation or ability to act. Although a definitive list of personal factors does not exist, a few should be standard considerations for any priority behavior under review.

- **Knowledge** refers to the accuracy of beliefs held by individuals regarding a reasonably well-established fact. For example, one-half of a residential target audience understands that storm drains and sanitary sewers are different. Depending on the objective, knowledge can be general as in this example, or very specific to a particular set of issues or practices (e.g., construction site BMPs, maintenance responsibilities for treatment control BMPs, or dog walking).
- **Awareness** is the recognition that something exists (a problem, an alternative, etc.). For example, are people aware that a local water body is polluted? Do they know that

their own actions might contribute to this problem? Without such awareness, it may be difficult to obtain their support, to increase their levels of knowledge, or to involve them in potential solutions. Awareness is fundamentally different than knowledge in that being aware of something does not imply any particular knowledge or understanding of it. Typical areas of awareness of interest to managers include:

- Awareness of water pollution impacts
- Awareness of the causes of water pollution
- Awareness of potential alternatives or solutions
- Awareness of stormwater programs and available resources

- **Attitudes** are favorable or unfavorable evaluations. They reflect the beliefs, feelings, values, and dispositions of individuals, and affect their willingness to engage in targeted behaviors. Regardless of how aware or knowledgeable a target audience is, they are unlikely to change behaviors if their attitudes toward water quality protection are unfavorable. For example, if residents feel that a vigorous tomato garden is more important than the condition of a nearby creek, or that BMPs represent unnecessary government intrusion, program implementation strategies will likely need to go beyond providing them informational brochures.
- **Other personal factors** such as emotional responses, habits, levels of commitment, or inability to remember information or change habits can also play a role in how changes are affected in individuals. With experience, managers are likely to identify many such attributes.

Table 5.12 provides examples of personal factors as they apply to a variety of different behaviors. In practice, distinctions between knowledge and awareness are sometimes likely to become blurred. In this respect, thoroughness is much more important than classification. Ultimately it matters less that a factor is correctly classified than it does that it is identified.

Table 5.12: Examples of Personal Factors that Can Affect Behaviors

	Pesticide Use	Vehicle Washing	Disposal of Reusables	Sediment Discharge
Knowledge	Proper methods of pesticide application	Controllable spray nozzles can significantly reduce runoff	Compost piles should be turned at least weekly	Silt fences should not be used at the base of a slope
Awareness	My pesticides can harm aquatic life	Commercial car washes minimize runoff	Training on composting is locally available	Discharges can be reported to a local hotline
Attitudes	Healthy plants are more important than environmental protection	People have a right to wash their cars on the street	Composting is too messy to bother with	Construction will be completed long before anyone notices our runoff

It's often assumed that increases in knowledge or awareness are sufficient to bring about changes in behavior. While it's generally true that both are necessary components of behavioral change strategies, it's also true that they cannot bring about such changes alone. Cost increases are an obvious example of an influence that can easily undermine increases in knowledge or awareness. In this respect, the external factors described below should also be given consideration. Despite the obvious temptation, managers should be wary of implementation strategies that rely exclusively on increasing knowledge or awareness to bring about change.

External factors also influence behavior, but are not within the ability of an individual to directly control. Examples include costs of compliance, the convenience of an activity, or peer pressure. It's not possible to describe all of the external factors that might apply to a target audience behavior, but the categories below should provide a fairly thorough starting point. Managers are encouraged to use them as a general guide, but should add other categories or factors as needed. **Table 5.12** provides examples of external factors as they apply to a variety of different behaviors.

- **Regulatory factors** -- People are bound by laws, regulations, and ordinances, which in many cases provide clear directives on what they can, can't, or must do. For example, some pesticides can be legally obtained and applied only by licensed pest control applicators, while others are available without restriction to homeowners. In this case, patterns of usage will clearly be influenced by existing regulations. Examples of other regulatory factors that can shape target audience behavior include building codes and zoning restrictions.

- **Economic factors** – Most practices or controls have costs associated with them. When given a choice, people will generally pick alternatives that are inexpensive, especially in the short-term. In many cases, PGAs exist because they represent a low cost alternative. It may be difficult to move a target audience toward an environmentally preferable alternative if it is viewed as too expensive (or difficult or time consuming). In such cases, costs may need to be reduced, financial incentives provided, or other strategies (e.g., stronger regulatory directives) put in place to offset the impact of costs. In addition, short-term costs of alternatives may be acceptable to some audiences, if there are demonstrable long-term savings, and especially if coupled with increased effectiveness.
- **Technological factors** – Technology is a cornerstone of effective stormwater management. As a wider variety of products and technologies is made available, residents and businesses are provided with an increasing array of BMP options. For example, porous pavement, a type of asphalt or concrete pavement that allows water to drain through, is now being increasingly used in a variety of applications. Another example is storm drain inserts, which continue to improve in efficiency and cost-effectiveness. In many cases, environmentally preferable technologies exist, but there may not be a willingness to try them until they are less expensive, more readily available, or better established as industry norms. It should also be noted that the influence of technology is less important for the many practices that rely primarily on simple choices (sweeping rather than hosing, using doggy bags to pick up after pets, etc.).
- **Structural factors** – Structural factors refer to adequacy of systems, sites, or structures to support a particular behavior or set of practices. For example, topography or space limitations might inhibit the use of treatment controls on a new development site, or present safety concerns during maintenance. While structural factors can sometimes be limiting, they can also present opportunities. For instance, a community garden might provide residents access to composting bins that they could otherwise not afford or don't have the space for.

- **Organizational factors** – At work and in their personal lives, most people are part of one or more organizations (companies, agencies, homeowners associations, industry associations, etc.). Within an organization, individuals can be influenced by a variety of factors such as leadership, individual or group roles and responsibilities, expectations and accountability, information dissemination, resource commitments, and opportunities for involvement or providing input.
- **Societal factors** – Societal factors are similar to organizational factors, but generally apply at a broader level. People live in and identify with others in their communities, cities, and states. Likewise, many of them also strongly identify with specific cultural or ethnic backgrounds or groups. People are generally most influenced by the groups they identify most strongly with. As such, peer pressure and social and cultural norms can be very powerful influences on behavior. In some cases, these factors can be used to overcome long standing habits and to increase commitment to a BMP alternative. For example, recycling is now a well-established practice in most communities, and it's much less common to see someone throw a recycle into a trash container than it was twenty years ago.
- **Communication factors** – In today's world, people receive more information in more different ways than they ever have. Despite this, information on stormwater management practices constitutes a very small portion of their daily information dosage. As already noted, people are unlikely to engage in behaviors they are not aware of or knowledgeable about. Communication is therefore critical to establishing behavioral norms at homes, businesses, and elsewhere. If residents lack information on pesticide alternatives they won't try them. Or if a business fails to communicate its recycling and reuse policy to employees they can't be expected to follow it. Conversely if people receive messages that support the use of existing PGAs (e.g., advertisements that show people mowing luxuriant lawns or washing cars in their driveways), they are more likely to continue them.

Table 5.13: Examples of How External Factors Can Influence Behavior

	Pesticide Use	Vehicle Washing	Disposal of Reusables	Sediment Discharges
Regulatory factors	Some pesticides can be applied only by licensed pest control applicators; others are freely available	A program prohibits discharges from businesses, but not at residences	Re-use of materials is encouraged rather than legally required	Ordinances prohibit discharges, but do not require prevention through erosion control practices
Economic factors	Many pesticides are inexpensive or cheaper in large quantities	Washing in a driveway is cheaper than using a car wash	Changes in practices may require upfront investments (e.g., composting bins)	Materials needed for stabilization projects can be expensive
Technological factors	Effective alternatives may not be available, or may require additional labor and training	Controllable spray nozzles are widely available	Technologies are not widely available for recycling of "higher numbered" materials	A variety of products are available for effectively managing discharges
Structural factors	Site safety issues limit the use of pesticide alternatives	A nearby parking lot with a pervious surface could facilitate environmentally friendly car washing	A community garden provides residents access to composting bins	Site topography or space limitations inhibit the use of sediment control practices
Organizational factors	A business lacks a policy or procedures on pesticide use	A company has an offsite vehicle washing policy	Employees are encouraged to recycle and reuse	Site maintenance is not an organizational priority
Societal factors	Green lawns are perceived by a community to be linked to pesticide application	Washing soapy water onto streets is considered "low class"	Composting is valued by the community	Sediment discharges onto public streets are considered unsightly
Communication factors	Residents lack information on pesticide alternatives	Information on "dry washing" techniques is widely available	Recycling and reuse policy is not communicated to employees	Information on effective erosion control practices is not widely available

Nature and Magnitude

Influencing factors can act on behaviors in a limited number of ways. Two aspects are essential, nature and magnitude.

In general, the **nature** of an influencing factor is either to support or inhibit a behavior. As shown in **Figure 5.16**, there are six general ways that a factor can potentially influence a behavior.

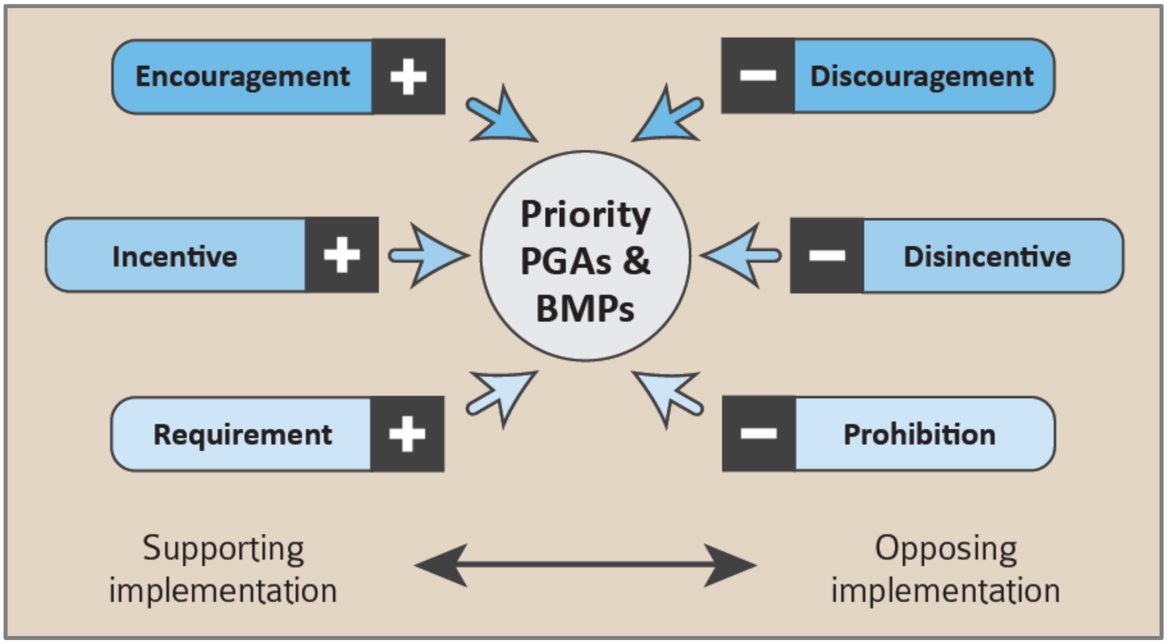


Figure 5.16: Different Ways that a Factor Can Influence Behaviors

This figure represents a continuum of possible forms of influence. In cases where a factor supports, or will later be targeted to support, a behavior, it will correspond to one of the three methods to the left of center on the figure. Likewise, the three methods to the right of center would generally be considered to work against the implementation of a behavior. As shown, each of these three pairs of opposites is fundamentally different in the way that it influences. In concept, the requirement and prohibition of practices (BMPs and PGAs, respectively) represent the strongest or most absolute type of influence, but this is not always so in practice. Consider, for example, legal requirements that are ignored or unenforced. Incentives and disincentives occupy a middle ground. Examples of factors that can act as incentives or disincentives to maintain or discontinue a behavior include peer pressure from social groups or within organizations, or an offset to a high BMP cost through a rebate. Encouragement and discouragement often align with educational approaches, and may sometimes appear to be the weakest of the forms shown. However, this isn't necessarily so. When sufficiently resourced or combined with other factors, changes in knowledge and awareness can have important impacts on existing or targeted behaviors.

As implied, the **magnitude** of the influence exerted is also important. In most cases, multiple factors are likely to be working together to influence a particular behavior, so it’s necessary to understand the relative “push or pull” of each.

Assignments of magnitude are necessarily subjective, and it would clearly not be possible to establish a common quantifiable metric across all influence types (knowledge, regulatory, etc.). The objective here is not pinpoint accuracy. General approximations of magnitude are more than adequate for helping managers to understand which factors are driving each PGA or BMP, and how they work together to do so.

Once both nature and magnitude are characterized, they can be considered together to provide a basic description of the condition. The following illustrates four possible ways of describing “encouragement” influences:

- ☐ No influence
- ☐ Weak encouragement
- ☐ Moderate encouragement
- ☐ Strong encouragement

This scheme can be applied in exactly the same way to the other five types of influence.

At this point, the task of managers is simply to characterize how and to what degree influencing factors might be exerting control over a behavior. This will be especially important during Level 1 planning as implementation strategies are developed to break down PGAs and replace them with BMPs.

Variability

Nature and magnitude can say a lot about an influencing factor, but are not always good predictors of the effect it will have. Whenever possible, its **variability** should also be considered. Some influencing factors might reasonably be expected to vary according to predictable cycles (e.g., seasonally or during business hours), and others might be temporary or unsustainable. For example, legal restrictions on water use might be instituted seasonally or only during severe drought conditions. Likewise, levels of knowledge in a target audience could peak during a school semester, immediately after a training session, or during a media campaign. Influencing factors can also vary spatially. For example, knowledge or awareness of a pollution impact might be very different in distinct communities (based on educational levels, patterns of program implementation, etc.).

One important aspect of variability is the **prevalence** of a barrier or bridge. For example, a strict ordinance provision (i.e., a "strong prohibition") might be viewed as an effective means of increasing water conservation. While true in concept, it might not be so if people are unaware of it or ignore it. Likewise, effective BMP technologies may exist for a particular application (i.e., a "strong encouragement"), but not be prevalent because of high costs or limited distribution.

Certainty

Certainty refers to the degree of confidence that managers have in the existence or attributes of an influencing factor. Managers will want to avoid expending significant program resources in addressing a factor that is not well-established or well-understood. For example, knowledge of a BMP alternative might be assumed to be lacking in a target audience, but without survey data or some other form of confirmation results might be uncertain. This might present a risk of needlessly investing in education when other influencing factors are more important.

Significant data and information gaps are very likely to be encountered during the evaluation of influencing factors. It's very likely that managers will need to speculate or hypothesize on the potential roles of influencing factors during this process. This is highly encouraged given the need to fully explore the range of potential factors acting on any behavior. It's important, though, to continue working toward eventual confirmation of factors that are initially not well understood.

Controllability

Controllability refers to the potential for a program to modify an identified influencing factor. A factor that does not have a reasonable chance of being successfully controlled may ultimately not be a likely priority for resource commitments. For example, regulatory barriers (e.g., seasonal restrictions on channel cleaning), or economic factors such as the costs of BMPs, can sometimes be beyond the ability of a local program to control.

Question 2 How are influencing factors changing over time?

A final consideration in evaluating influencing factors is their temporal change. Like other outcome types, influencing factors can often be expected to change over time.

Understanding these changes can have important explanatory benefits for similar changes observed or predicted in PGAs or BMPs.

Managers should be interested in knowing whether an influencing factor is **trending** upward or downward over time. As an example, the costs of a control measure are decreasing over time as technological improvements are made or markets evolve to satisfy a demand. Or communication within a company is increasing along with organizational commitment to sustainable practices.

Changes in influencing factors due to program implementation can often be expected, or may have already occurred, as a result of implementing programs that act on them. For example, changes in awareness as a result of ongoing media campaigns are well documented for many programs. Likewise, more businesses maintain stormwater pollution plans onsite and conduct routine employee training than in the past. Whether or not these are sustainable trends is another question, but program implementation undeniably plays an important role in shaping changes in many influencing factors.

Direction of Influence -- Barriers versus Bridges

Any of the factors identified above can influence behavior in either of two ways. Factors that influence "negatively" (i.e., favoring the implementation of PGAs, or inhibiting the implementation of BMPs or other targeted behaviors) are considered **Barriers**. A typical barrier for many target audiences is a lack of knowledge. Consider, for example, a situation where residents are unaware that spraying pesticides before it rains is harmful, or that less toxic alternatives are available. Without this knowledge, they may be unlikely to engage in practices that are protective of water quality. The designation of barriers is explored further in **Task 2** (Identifying Barriers).

Factors that influence "positively" (i.e., promoting the implementation of BMPs or reducing the impact of PGAs) are considered **Bridges**. A bridge either modifies or offsets a barrier. Using the same example, a higher level of awareness in residents regarding pesticide practices and impacts could be considered a bridge toward the implementation of preferable behaviors. Likewise, if cost or convenience had instead been the identified as barriers, potential bridges might have included the establishment of economic incentives or increases in the availability of alternative products. Bridges represent potential solutions. In most cases, they reflect potential rather than actual conditions. Bridges are considered further in **Step 2-B**.

At this stage, a number of critical parameters have been identified for use in completing a **Task 1** characterization of potential influencing factors. **Figure 5.17** below provides a **Review Checklist** to help guide managers through these reviews. The final output of Task 1 will be a listing of, and corresponding documentation for, all of the factors potentially influencing each of the priority PGA-BMP packages identified during Level 3 planning.

Review Checklist

Step 2-A Task 1

Identifying Influencing Factors

Apply this task very broadly across Outcome Level 2 sources of data and information. The purpose is to provide a "snapshot" of what is currently known about influencing factors.

- ✓ **Compile existing influencing factor data, information, and results. Consider the following questions:**

  Question 1: What factors influence priority target audience behaviors?

  Question 2: How are influencing factors changing over time?

- ✓ **Consolidate results into one or more summary lists of existing conditions. Categorize results as determined appropriate (by factor type, etc.).**
- ✓ **Compile supporting documentation for listed factors.**
- ✓ **Select the influencing factors in the summary list(s) that will be further evaluated as potential problems in Task 2. Consider "back-up" lists for future evaluation as necessary.**
- ✓ **Document the critical data and information gaps identified during Task 1 completion.**

NOTES

Figure 5.17: Review Checklist for Evaluating Influencing Factors

Task 2 Defining Barriers

In **Task 1**, managers explored the range of factors influencing the behaviors in a **PGA-BMP package**. **Task 2** completion will focus on identifying which of these factors are acting as barriers, i.e., contributing to behavioral problems. These barriers will be prioritized in **Task 3** and later considered in the development of management strategies.

Source contributions are presumed to result when the net influence of all factors acting on a package favors the implementation of PGAs over BMP alternatives. A useful analogy is to envision barriers and bridges as weights loaded onto the opposite pans of the balancing scale shown in **Figure 5.18**.

When the weight of the barriers on the left exceeds that of the bridges on the right, the dial will move in the direction of PGAs, a condition that should in turn cause source contributions. If this "negative balance" is shifted in the other direction, the result should be a reduction in PGAs or an increase in BMPs with a resultant decrease in source contributions. Managers will want to design and implement strategies that affect a shift toward this "positive balance" – either by removing barriers or by adding bridges.

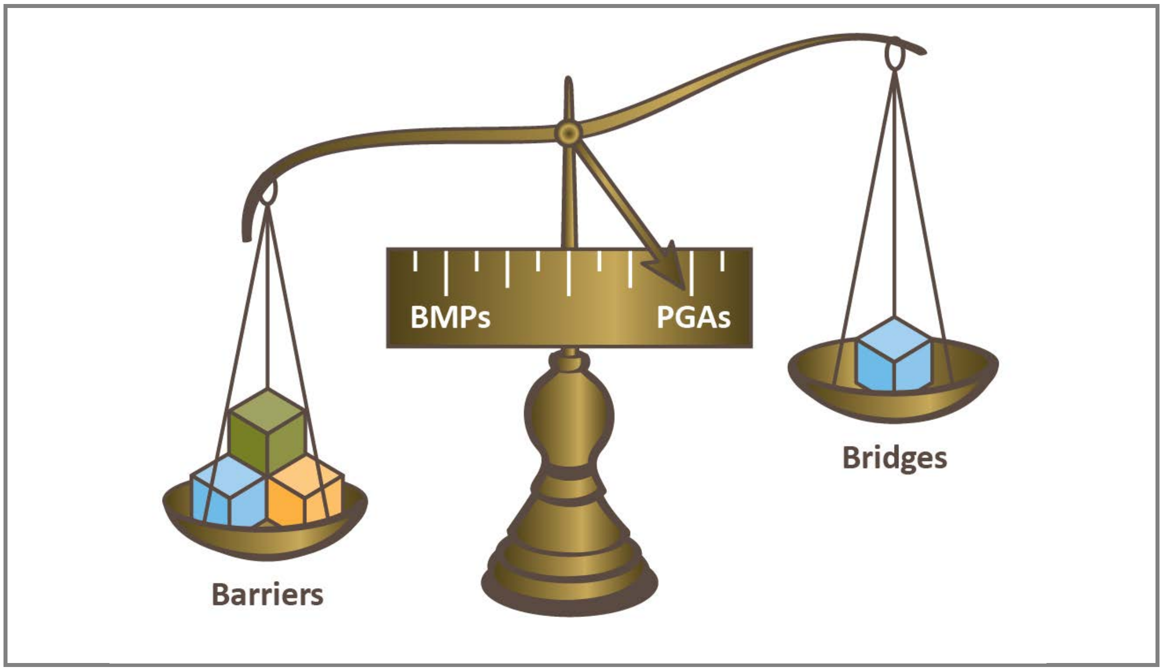


Figure 5.18: A Balance of Barriers and Bridges that Favors PGA Implementation

In setting out to achieve a positive balance, managers need to know how and why the current negative balance exists. To do so, they will further evaluate each of the **Influencing Factors List** identified in **Task 1**, using two key questions to guide this review.

Step 2-A Task 2 Key Questions
Defining Barriers

Inputs	Key Questions	Outputs
Identified Influencing Factors	**Question 1:** Which influencing factors are barriers? **Question 2:** What is the collective influence of identified barriers?	**Problem Factors (Barriers)**

Question 1 Which influencing factors are barriers?

Influencing factors that favor the implementation of PGAs, or that inhibit the implementation of BMPs or other targeted behaviors, are barriers. Three general types of barriers are described below. These three types will form the basis for a corresponding classification of bridges later discussed under **Task 3**.

Barriers that Support PGAs

Type 1 Barriers consist exclusively of influencing factors that favor PGAs. **Table 5.14** provides examples of Type 1 Barriers contributing to pesticide over-application. Whether considered individually or together, each factor contributes in some way toward the continued existence of the PGA. PGA-supporting factors are the most common types of barriers for the obvious reason that existing source contributions are caused by PGAs.

Table 5.14: Examples of Factors that Support PGAs

Type of Factor	Example of Barrier
Knowledge	A lack of knowledge that pesticides should be applied according to label instructions results in residents assuming that "more is better";
Cost	The pesticide is inexpensive or cheaper in large quantities; or
Attitudes	Residents place a high value on insect-free vegetables and believe that insecticides are necessary to achieve them.

In some cases, an influencing factor can also act as a barrier because of its impact on one or more BMPs. Two types of influencing factors that act on BMPs are considered below. It should be emphasized that the net influence of these factors is identical to that of a PGA-supporting factor in that all contribute to source loadings. But the distinction between them is critical because managers will have to decide whether their implementation strategies will focus on the PGA, the BMP, or both.

Barriers that Inhibit BMPs

Type 2 barriers are those that inhibit the implementation of BMPs. They can do so in either of two ways.

a. Insufficient support for existing BMPs

In this case, a factor that could support BMP implementation is either too weak or not prevalent enough to do so. Because these factors have the potential to influence positively, they can also be described as "weak bridges." Considering pesticide application again, **Table 5.15** provides examples of these barriers.

Table 5.15: Examples of Factors that Provide Weak Support for Existing BMPs

Type of Factor	Example of Barrier
Knowledge	Some knowledge of proper techniques for applying pesticides exists, but it is very limited.
Organizational	A business has strict policies on pesticide application, but employees are unaware of it.
Regulatory	Legal restrictions on pesticide application exist, but are largely ignored.

The common element in each example is the limited existence of a factor that has the potential for positive influence. In spite of this potential, each factor is currently acting as a barrier because its overall influence is too limited to provide a bridge. In cases like this, BMPs that might otherwise offset PGA contributions instead represent "lost opportunities".

b. Inhibition of BMP alternatives

These barriers act on identified BMP alternatives. An essential component of the PGA-BMP Packages developed in Level 3 planning is the establishment of these alternatives. These barriers are those that inhibit their implementation. **Table 5.16** provides examples associated with a less toxic pest control product identified as an alternative to pesticide application.

Table 5.16: Examples of Factors that Inhibit BMP Alternatives

Type of Factor	Example of Barrier
Awareness	People are unaware that the alternative product exists.
Technology	The alternative product is less effective than the pesticide.
Cost	The cost of the alternative product is high.
Attitude	People perceive that the product is unsafe, complicated, or ineffective.

BMP alternatives are the core of effective management strategies, so it's important to understand which influencing factors will either support or inhibit their implementation. Without this knowledge, managers risk committing to misdirected or ineffective implementation strategies.

Question 2 What is the collective influence of identified barriers?

Once barriers are identified, it's important to further consider how they impact each of the priority behaviors in the PGA-BMP package. Two issues are critical. First, it's useful to consider how individual barriers are (or are not) related to each other. This is accomplished by placing them in groupings under each priority behavior. It's possible that some barriers will act on multiple behaviors (e.g., two separate BMP alternatives). In such case, they should be listed as many times as applicable.

Figure 5.19 provides a very simple illustration of how barriers can be grouped. Starting with the complete list of barriers on the left, each individual barrier is placed under one or more of the priority behaviors. This allows managers to view the applicable barriers as a discrete package, and to associate each barrier with only those others that it is related to.

Figure 5.19: Grouping of Barriers by Priority Behavior

It's also important to understand the nature of each barrier's impact within its respective grouping. While all barriers theoretically contribute to their respective behaviors, each influences in different ways and degrees. In some cases it may be obvious which factors have the greatest influence on a behavior. In cases where more information is needed, surveys, focus groups or target audience interviews provide insights regarding personal factors that will influence behavior. A review of existing regulations, costs of PGAs and BMPs, and other observations of existing conditions should be helpful for identifying significant external factors that may be causally linked to a behavior.

In Task 1, a range of attributes were identified for each influencing factor. Reviewing these results together provides a general indication of the potential influence of each identified barrier. **Table 5.17** provides an example of how attribute information for various barriers can be summarized. This is essentially a review of what is known so far, and preparation for prioritization (**Task 3**).

Table 5.17: Summarizing Attributes of Barriers by Priority Behavior[7]

Barrier	Description	Nature and Magnitude	Prevalence	Certainty	Controllability
PGA: Over-application of fertilizers					
Barrier 5	Lack of awareness of impacts	Weak encouragement	High	Uncertain	Moderate
Barrier 6	Low cost of fertilizers	Moderate encouragement	Moderate	Low	Low
Barrier 1	Community values green lawns	Moderate requirement	Unknown	Moderate	Unknown
Existing BMP: Change timing of applications					
Barrier 1	Inconvenience of BMP	Moderate discouragement	Unknown	Moderate	Low
Barrier 2	Low awareness of BMP	Strong discouragement	Unknown	Moderate	Moderate
BMP Alternative: Use smaller amounts or alternative formulations					
Barrier 3	Higher cost	Weak encouragement	High	High	Not controllable
Barrier 4	Perceived ineffectiveness	Strong discouragement	Moderate	High	Low
Barrier 1	Lack of awareness of alternative	Moderate incentive	Unknown	Moderate	Moderate

[7] These examples are hypothetical and for illustration only. They are not intended to imply the existence of any particular attributes for any of the barriers listed.

The importance of understanding relationships between barriers and behaviors cannot be overstated. However, it can be challenging to do so with confidence because neither tends to be easily observable. Moreover, even when the existence of a potential influencing factor can be verified, it may still not be possible to establish a linkage to a PGA or BMP. In most instances, some degree of speculation is needed, and managers will need to rely heavily on judgment and experience. Those that are willing to speculate on the causes of problem behaviors and to implement and evaluate potential solutions should become increasing confident in their assessment of barriers over time.

It's recommended that managers utilize the **Task 2 Review Checklist** provided below (**Figure 5.20**) in evaluating barriers. This will ensure that reviews are comprehensive and that all obvious bases are covered. Over time, the Review Checklist can be modified to reflect individual experience. In some cases, working assumptions about barriers will be guided by available data and information (survey results, economic data, etc.). In others, a lack of data availability may force managers to substitute their own best professional judgment in establishing working assumptions about barriers. In either case, best professional judgment should always be part of the equation. Wherever possible, working assumptions should be verified up front to reduce uncertainty during subsequent implementation and assessment phases. However, this isn't always realistic, so managers will often need to make the best guesses they can, and then implement and assess. This trial-and-error approach provides an important alternative for real world application.

Review Checklist

Step 2-A Task 2

Defining Barriers

Apply this task individually to each Task 1 influencing factor selected for further evaluation. The purpose of this task is to determine which of these should be designated as problems.

✓ **For each identified influencing factor, consider the following questions:**

Question 1: Which influencing factors are barriers?

Question 2: What is the collective influence of identified barriers?

✓ **Document known or suspected barriers.**

✓ **Consolidate results into one or more summary lists. Categorize results as determined appropriate (by behavior, barrier type, etc.).**

✓ **Compile supporting documentation for listed barriers.**

✓ **Document the critical data and information gaps identified during Task 2 completion.**

NOTES

Figure 5.20: Review Checklist for Defining Barriers

Task 3 Prioritizing Barriers

Once the barriers influencing a PGA-BMP package are identified, a priority rating can be established for each of them. This consists of setting a value for the priority of each barrier (e.g., high, medium, or low). In itself, this implies little for the establishment of management priorities because not all priority barriers can be targeted for change. Ratings should also be compared to each other to assign relative rankings. Prioritization is guided by the key questions below.

Step 2-A Task 3 Key Questions
Prioritizing Barriers

Inputs	Key Questions	Outputs
Identified Barriers	**Question 1:** What is the individual priority rating of each barrier? **Question 2:** What is the relative importance of each barrier?	**Priority Barriers**

Prioritization follows a two-step process (**Figure 5.21**). Each problem is first reviewed to determine its priority rating. Ratings are then considered together to determine their relative priority ranking. Managers may already have other preferred approaches than those described, and should choose those that work best for them.

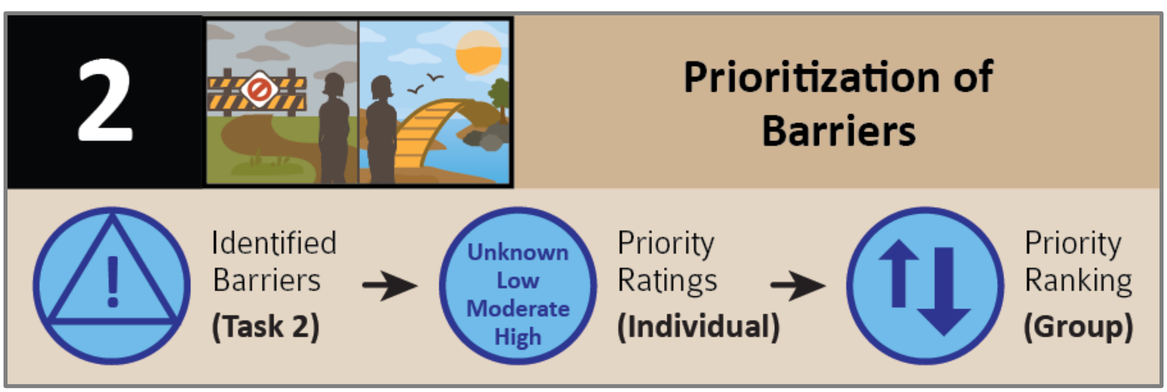


Figure 5.21: General Process for Prioritizing Problem Behaviors

Question 1 What is the individual priority rating of each barrier?

Establishment of priority ratings establishes a value for the priority of each identified barrier. This is approached through a combination of the first two review tiers introduced in **Section 3.2**[8] that emphasizes both the relative influence of each factor and its potential for influence by stormwater programs. As previously described for other Levels, simple rating schemes are recommended for all review factors.

Tier 1 Regulatory Screening

Tier 1 is a simple screening step. If a barrier to change is legally required or prohibited (e.g., zoning that prohibits certain activities or features), or is otherwise meaningfully affected by legal or regulatory requirements, it may be difficult or impossible to modify. If so, managers will need to decide if it makes sense to further consider the barrier as a potential priority. It's also important to determine if regulatory requirements conflict with other prioritizing considerations. To overcome conflicting barriers, they may need to work with the regulatory authority on modifying the regulation or identifying alternative approaches.

Tier 2 Technical Review

For the most part, the priority rating will reflect a combination of its significance, certainty, and controllability. **Significance** refers to the nature, magnitude, and variability of a barrier. Each of these attributes will already have been considered in Task 1, so this is primarily a review and consideration of those results. Ideally the litmus test for significance is a clear understanding of how and to what degree the removal of a barrier would make a measurable reduction in a PGA. In practice, this is usually not the case since quantifiable linkages between barriers and behaviors have usually not been established. Over time, as barriers and behavioral outcomes become increasingly well-quantified, it may be more realistic to pursue these relationships. Certainly managers should look to quantifiable linkages as an ideal, but this shouldn't stop them from aggressively hypothesizing and exploring linkages, either qualitatively or quantitatively.

[8] The third tier (Sustainability Review) is not included for Level 2 prioritization because economic and social considerations are "built into" the initial identification of influencing factors. As such, they are already reflected.

In designating an overall value for significance, managers will need to decide how to weigh each of the three contributing criteria. Magnitude and prevalence will usually be the most straightforward to interpret because they more easily lend themselves to some form of quantification. As discussed previously, barriers can have many different natures (encouragement, prohibition, incentives, etc.), and the potential of each to positively or negatively influence a behavior can be quite different. This is not to say that nature is less important, but interpretation may require greater discretion.

Certainty describes the confidence that managers have in their understanding of a barrier. Because they want to avoid committing resources toward addressing a factor that is not well-established, certainty will tend to be positively correlated with priority (i.e., the higher the certainty, the higher the priority).

Controllability is the potential for a program to control or modify an identified barrier. Low controllability factors may also not be priorities for potential resource commitments. Controllability should also correlate positively with priority.

Assignment of Priority Ratings

Utilizing each of factors described above, an **individual priority rating** should be assigned to each barrier (**Table 5.18**). The particular methodologies used to weigh contributing criteria are left to the discretion of managers. However, complex weighting schemes are generally discouraged because of the qualitative nature of the exercise.

At this point, ratings are assigned individually, and have nothing to do with the respective priorities of other barriers. An example of potential ratings is as follows, but managers should feel comfortable substituting any designations they consider appropriate (0-1-2-3, A-B-C-D, etc.).

- ☐ Unknown priority
- ☐ Low priority
- ☐ Moderate priority
- ☐ High priority

Table 5.18 illustrates several examples of the assignment of priority ratings to barriers and potential BMP alternatives initially identified in **Table 5.17**. In each instance, assignments are purely qualitative in that the individual designations for each rating factor are more or less lined up, with an overall priority rating being estimated by “eyeballing” the collective weight of the results. This emphasizes the subjective nature of scoring processes. Managers should avoid being too literal in the interpretation of results.

Table 5.18: Examples of Rating Assignments for Individual Barriers[9]

Barriers and BMP Alternatives	Tier 1: Regulatory Screening	Tier 2: Technical Rating				Overall Priority Rating
		Significance	*Certainty*	*Controllability*	*Overall*	
PGA: Over-application of fertilizers						
Lack of awareness of impacts	**Weak**	Moderate	Unknown	Moderate	**Moderate**	**Moderate**
Low cost of fertilizers	**Unknown**	Moderate	Low	Low	**Low**	**Low**
Community values green lawns	**Unknown**	Moderate	Moderate	Unknown	**Moderate**	**Low-Mod**
Existing BMP: Change timing of applications						
Inconvenience of BMP	**Weak**	Moderate	Unknown	Moderate	**Low**	**Low-Mod**
Low awareness of BMP	**Weak**	Moderate	Unknown	Moderate	**Low**	**Low-Mod**
BMP Alternative: Use smaller amounts or alternative formulations						
Higher cost	**Unknown**	Moderate	High	High	**Moderate**	**Mod-High**
Perceived ineffectiveness	**Weak**	Moderate	Moderate	High	**Moderate**	**Mod-High**
Lack of awareness of alternative	**Weak**	Moderate	Unknown	Moderate	**Unknown**	**Mod-High**

[9] These examples are hypothetical and for illustration only. They are not intended to imply a particular priority for any of the influencing factors listed.

These examples assume an equal weighting for each contributing factor, but the actual weighting would be determined by the manager conducting the exercise. It's also possible to assign continuously distributed values (1.2, 3.7, etc.) to individual rating factors and to the ratings themselves, but this implies a level of precision that may not exist. In most cases, qualitative ratings are appropriate and reasonable for prioritizing barriers.

Question 2 How are barriers ranked?

Question 1 dealt with rating barriers individually, but for these ratings to be useful in supporting decision-making, they must be evaluated together to determine their *relative* importance. Identified barriers can either be put into a rank order or be grouped by priority. **Figure 5.22** illustrates each approach.

	RANKED ORDER EXAMPLE		**GROUPED RANKING EXAMPLE**	
	Supporting PGAs	**Inhibiting BMP Alternatives**	**Supporting PGAs**	**Inhibiting BMP Alternatives**
↑ Increasing Priority ↑	Barrier 3 Barrier 1 Barrier 2 Barrier 5	Barrier 7 Barrier 6 Barrier 4	**Group A Barriers** 3, 1, 2 **Group B Barriers** 5	**Group A Alternatives** 7 **Group B Alternatives** 6, 4

Figure 5.22: Examples of Ranked Order and Group Ranking of Priority Barriers

Establishing ranked orders is a fairly straightforward process. For each behavior associated with a given PGA or BMP, the applicable barriers are lined up from highest priority to lowest, with the higher priorities constituting the greater management priorities. The downside to ranked order approaches is that barriers will tend to lump together because of "tie scores". In such cases, managers may want to instead consider grouped rankings.

The simplest way to approach grouped rankings is again to look at all of the barriers associated with a given PGA or BMP. For each behavior, the highest priorities for management action will be the barriers in the highest priority groupings (in this case, Group A). Looking instead at the PGA-BMP package as a whole, it's also possible to group barriers across multiple behaviors. There is an inherent logic to this in cases where some barriers act on multiple behaviors. This is really a judgment call, but managers should be aware of the additional complexity that may be entailed in doing so.

The final output of **Task 3** will be a ranked list of priority barriers influencing each identified barrier or PGA-BMP package. **Figure 5.23** below provides a **Review Checklist** to help guide both phases of this prioritization process. As in previous steps, significant data and information gaps are likely to be encountered along the way. It's critical to document these deficiencies and consider them in the development of future data collection strategies.

Review Checklist

Step 2-A Task 3

Prioritizing Barriers

Apply this task individually to all problem conditions identified in Task 2. Its purpose is to assess and rank the priorities of identified barriers.

✓ **For each identified barrier, consider the following questions:**

Question 1: What is the individual priority rating of each barrier?

☐ **Tier 1: Regulatory Screening** **REGULATORY RATING ________**

- ✓ Identify regulatory requirements and constraints affecting the barrier.
- ✓ Based on their collective impact, assign a Tier 1 rating.
- ✓ Note the overall direction of influence of the rating (requirement or constraint).
- ✓ Should an Overall Priority Rating be assigned based solely on regulatory criteria? If yes, stop and document. If no, continue to Tier 2 Review.

☐ **Tier 2: Technical Review** **TECHNICAL RATING ________**

- ✓ Evaluate the significance, certainty, and controllability of the barrier. Establish individual weightings as appropriate for each of the three factors.
- ✓ Based on review of the above factors, assign a Tier 2 Rating.
- ✓ Should the problem be eliminated from further consideration or assigned a "low" Overall Priority Rating based solely on technical criteria? If yes, stop and document. If no, continue to Tier 3 Review.

☐ **Tier 3: Sustainability Review** **SUSTAINABILITY RATING(S) ________**

- ✓ Identify economic factors and social factors affecting priority.
- ✓ Assign a Tier 3 Rating (or Ratings) either collectively for economic and social factors, or for each individually.

☐ **Overall Priority Rating** **OVERALL PRIORITY RATING ________**

- ✓ Collectively consider Regulatory, Technical, and Sustainability results to assign an Overall Priority Rating for the barrier. Assign individual weightings for each of the factors considered. Economic and Social factors may be counted individually or together.

Question 2: How are barriers ranked?

☐ **Rank individual priority ratings for further consideration in Step B.**

✓ **Document the critical data and information gaps identified during Task 3 completion.**

____

Figure 5.23: Step 2-A Task 3 Review Checklist

Step 2 - B Targeted Changes to Barriers and Bridges

Step 2-B deals with the establishment of bridges toward positive behavioral change. Bridges are the opposite of barriers. They influence behaviors "positively" either by promoting the implementation of BMPs or by reducing the impact of PGAs. Returning to the analogy introduced in **Step 2-A (Task 2)** above, the starting point for planning was an "imbalance" of the balancing scale in the direction of PGAs. As illustrated in **Figure 5.24**, the purpose of targeting is to set measurable objectives for restoring this balance in the direction of BMP implementation. This is achieved by increasing the weight of the bridges on the scale.

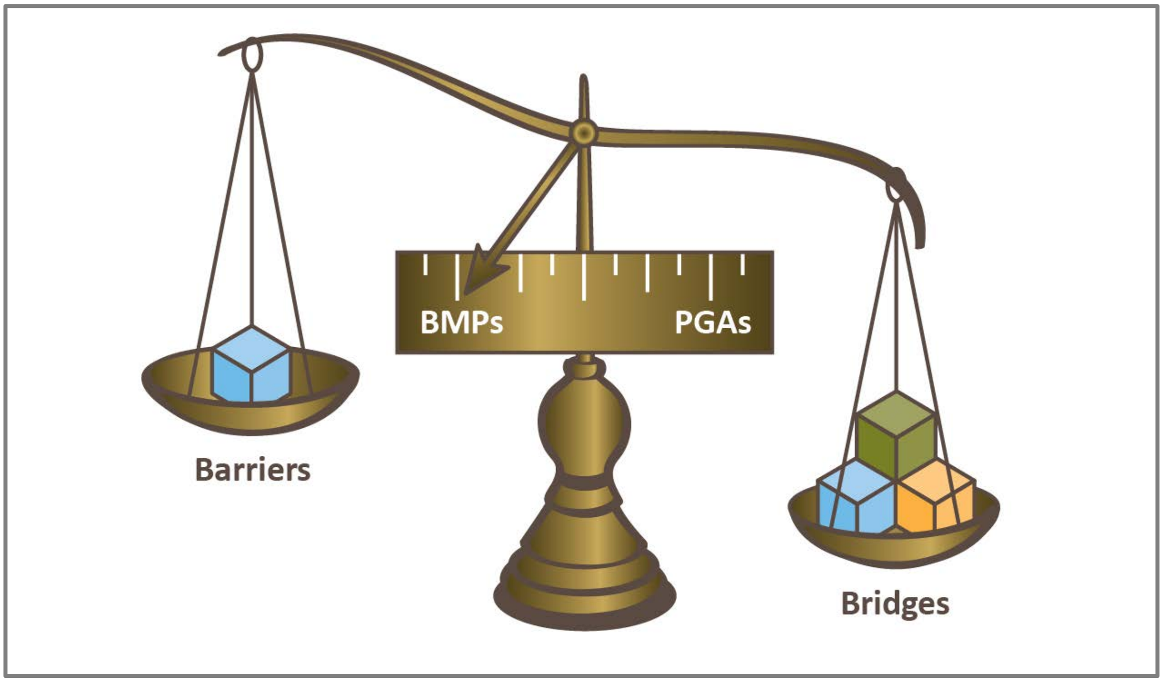


Figure 5.24: A Balance of Barriers and Bridges that Favors BMP Implementation

In **Step 2-A**, barriers were evaluated and their respective priorities determined. Once a barrier is determined to be a priority, and therefore warranting a resource commitment, managers can project the changes they want to see in it. **Step 2-B** provides guidance for targeting those changes.

The figure below identifies the inputs that are necessary for this planning step, the three tasks that need to be completed based on the inputs received, and the outputs that will be used to inform the next step in the planning process. Each task is described in additional detail below. As shown in **Figure 5.25**, targeting changes entails three distinct tasks. Targeting the specific outcomes that will constitute success is the first critical step in the development of management strategies. This provides a measurable basis for forecasting outcomes, and for measuring and evaluating change. Interim targets define an incremental pathway toward the achievement of longer-range goals. Once a pathway for achieving changes is projected, the metrics and methods needed to document and support their evaluation can be established.

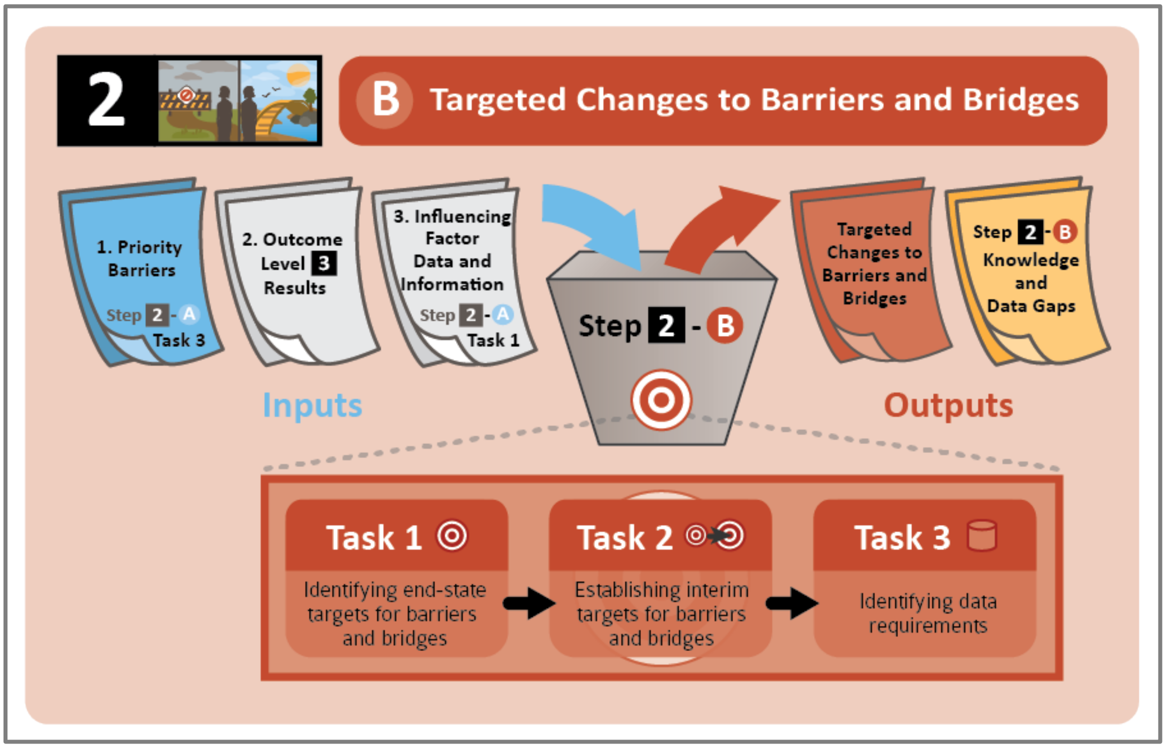


Figure 5.25: Targeted Changes to Barriers and Bridges (Step 2-B)

Task 1 Identifying end-state targets for change

This task addresses the identification changes in barriers and bridges needed to facilitate positive behavioral outcomes. It addresses two general questions.

Step 2-B Task 1 Key Questions
Identifying End-state Targets

Inputs	Key Questions	Outputs
Priority Problems (Barriers)	**Question 1:** What are the end-state targets for change? **Question 2:** When should the end-state targets be achieved?	**End-state Targets for Barriers and Bridges**

Question 1 What are the end-state targets for change?

On completion of Step 2-A above, managers should understand what the barriers are for each priority behavior. The next step will be to determine the changes they will seek in them. This will entail either a reduction in barriers or an increase in bridges. Targeting should always be considered provisional, and returned to periodically as results accumulate. In setting targets, the following should be considered.

Nature of the targeted change

Following on the categories of barriers previously identified, targeted changes can be grouped according to three corresponding types.

- ☐ **Inhibition of PGAs.** A change is targeted to inhibit the presence of an existing PGA (e.g., a regulatory ban of a pesticide). The bridge can either reduce or eliminate a barrier.
- ☐ **Strengthened support for existing BMPs.** A change is targeted to increase the magnitude or prevalence of an existing factor to more actively support BMP implementation (e.g., increase existing awareness of proper techniques for applying pesticides). The bridge can either replace or offset a barrier.
- ☐ **Support for BMP alternatives.** A change is targeted to actively support the implementation of an identified BMP alternative (e.g., incentivizing the cost of a less toxic product). The bridge can either replace or offset a barrier.

As an example, regulatory factors that serve as barriers were discussed above. Conversely, there may also be laws or regulations that support the desired BMPs or behaviors and, therefore, establish a bridge (e.g., bans for the use of certain pesticides, bans on the use of plastic bags). Ordinances can be very effective when used in concert with an inspection program (e.g., they can be implemented for commercial businesses to stop a PGA or implement a BMP). Whenever a PGA is eliminated due to a regulatory requirement, it is essential that education regarding an acceptable alternative behavior is offered to the target audience.

Magnitude of changes

Determining how much change is needed is one of the most challenging parts of the targeting process. For reducing barriers, there's no easy answer since multiple factors tend to act together, and the respective strength of their influences is not usually well-known. Since the bottom line is the net change across all factors, more success with one may allow for less with another. Conceptually, there are a few obvious starting points. The first of these is the total elimination of one or more barriers. Targeting to elimination is tempting because it eliminates ambiguity. If a barrier is gone, it cannot contribute to a PGA. However, while conceptually simple, elimination of barriers is not usually realistic. It generally makes more sense to seek targeted, measurable changes that can be evaluated and modified over time.

Setting Targets to Comply with Regulatory Requirements

Setting targets to regulatory requirements, particularly those established in permits, should always be considered up front. Most permits do not set explicit requirements for changes in influencing factors, but some do require measurable increases in knowledge and awareness in target audiences. These should be adhered to if applicable.

Setting Targets to Achieve Specific Level 3 Changes

This should be the preferred approach when targets have been defined for higher outcome level changes, <u>and</u> their relationship to the behavior is quantifiable. Since the magnitude of behavioral changes is assumed to be a function of the magnitude of its influencing factors, an increase or decrease in one should cause a corresponding change in the other. Ideally both endpoints are known and quantifiable. Where they are not, relationships between them can still be explored "experimentally" as described below.

Setting Targets to Resource Availability

Setting targets to resource availability is often necessary because programs don't always have the staffing, budget, or other resources needed to pursue targets for influencing factors established through other approaches. Resource availability presents real world constraints that must be considered, although it's important to remember that targets which are too low may not be effective. Rather than under-targeting because of resource limitations, it may make more sense to defer targeting some changes until additional resources can be obtained, or to divert those existing resources to another influencing factor. In early stages, the resource implications of characterizing influencing factors may tend to take precedence over those needed to pursue changes.

Setting Targets to Learn and Adapt

This approach involves establishing targets to explore the potential for changing the nature, magnitude, or "mix" of existing influencing factors. Because barriers and bridges are sequentially linked both to level 3 and 1 conditions, managers can benefit from exploring relationships to higher and lower level outcomes. One way of approaching this is through the establishment of **stretch targets**. For example, if 25% of a target audience is currently aware of a problem, a goal of 30% could be targeted over a defined period, and existing facilitation activities "dialed up" to try and achieve the change. Results could be periodically evaluated to see if increases are resulting and to adjust implementation strategies accordingly. An advantage to stretch targeting is that it allows efficiencies to be evaluated as activities are incrementally increased.

Experimental targets allow the exploration of relationships and testing of hypotheses. In the absence of specific information on the relationship of influencing factors to higher level changes, managers will often need to take a trial-and-error approach. Specific levels of change can be targeted and tracked along with ongoing assessment of behavioral change or program implementation. By exploring potential causal relationships, managers can learn what works and what doesn't.

Question 2 When should end-state targets be achieved?

Depending on the types of changes that are targeted, significant periods of time may be needed to reduce barriers or build bridges to behavioral change. In instances where programs exert a high degree of direct control (e.g., through building or grading permits), changes can occur very quickly, but in most instances managers should realistically expect that years or decades may be needed. Timeframes will tend to be shorter for target audiences that are influenced by regulations (commercial and industrial audiences) or municipal employees since the messages and target audience can be better controlled. For residential target audiences, barriers and bridges may be primarily addressed by voluntary actions, and may tend to take considerably longer.

Task 2 Establishing interim targets for influencing factors

This step identifies approaches to establishing the interim targets to assist in evaluating progress towards achieving the end-state targets. The key questions below can be used to identify the interim targets for the barriers and bridges.

Step 2-B Task 2 Key Questions
Establishing Interim Targets

Inputs	Key Questions	Outputs
End-state Targets for Barriers and Bridges	**Question 1:** What interim targets are needed to evaluate progress toward the end-state target? **Question 2:** When will interim targets be achieved?	**Interim Targets for Barriers and Bridges**

Question 1 What interim targets are needed to evaluate progress toward the end-state target?

Change is not linear, so managers should be realistic about what they can expect to see at any particular point in time. Consider a residential population with 5% overall awareness that overwatering of lawns contributes to pollution. If a 10-year goal of bringing this awareness to 80% is established, it would be naïve to expect that $1/10^{th}$ of this goal (i.e., a 7.5% increase) would be achieved each year. Realistically, allowances need to be made for the time it takes to "ramp up," refine, and fully implement a program. Likewise, there will be a point at which maximum gains should be expected, and quite possibly diminishing returns beyond after that. While it's straightforward enough to anticipate such changes in concept, it's not possible to accurately predict the curve.

Interim targets establish milestones along the way necessary to realistically anticipate critical events in the implementation curve, and to make adjustments in response to results. They allow progress to be measured and strategies to be adjusted along the way. They're critical to adaptive management.

Question 2 When will interim targets be achieved?

Timeframes for interim targets should reflect the initial schedule set for achieving the end-state condition, the need for specific feedback along the way, and the ability to measure change over interim periods. Interim targets should not be set so aggressively that it will be difficult to obtain useful feedback.

Task 3 Identifying data requirements

Now that targets for changes in barriers and bridges have been identified, it's necessary to identify how they will be measured, what data are needed to allow measurement, and how data will be collected and analyzed. Planning is not complete unless managers are ready to obtain and evaluate the data needed to assess each targeted change. Each of the questions below should be addressed for every targeted outcome addressed in **Step 6-B**.

Question 1 What metrics will be used?

Changes to influencing factors should both be expressed in unambiguous terms. This should include a specific formulation of the outcome statement, the assignment of units of measure or assessment, and units of time. **Section 7.3** provides additional detail on the establishment of metrics.

Question 2 What data collection methods will be used?

It's also essential that managers identify how data will be collected for each targeted barrier or bridge so that it can be tracked and assessed. **Section 7.4** provides additional detail on potential data collections options.

Question 3 What data analysis methods will be used?

The last consideration for any targeted influencing factor is how the data will be evaluated. The choice of analytical method can dictate what specific metrics should be used, how the data should be collected, and the quality of the result. **Section 7.5** provides additional discussion of data analysis options. Where the establishment of receiving water data requirements cannot be satisfactorily addressed up front (e.g., there's no available option for collecting the desired data), this may need to be documented as a knowledge and data gap (**Step 6-C**).

Figure 5.26 provides a Review Checklist to guide Step 2-B completion.

Review Checklist

Step 2-B Tasks 1, 2, and 3

Targeted Changes to Barriers and Bridges

Apply this task individually to all barriers identified in Step 2-A. Its purpose is to identify specific targets for change in these conditions.

✓ **End-state Targets (Task 1)**
Consider the following questions:

Question 1: What is the end-state for the barrier or bridge?
Question 2: When should the end-state condition be achieved?

✓ **Interim Targets (Task 2)**
Consider the following questions:

Question 1: What interim targets are needed to evaluate progress toward the end-state barrier or bridge?
Question 2: When will interim targets be achieved?

✓ **Data Requirements (Task 3)**
Consider the following questions:

Question 1: What metrics will be used?
Question 2: What data collection methods will be used?
Question 3: What data analysis methods will be used?

✓ **For each priority barrier or bridge, document interim and end-state targets, and the data requirements necessary to track and evaluate them.**

✓ **Compile one or more lists of targeted changes to barriers and bridges and supporting documentation for listed conditions.**

✓ **If a priority change to a barrier or bridge is not or cannot be targeted, document the reason.**

✓ **Document all Step B data and information gaps.**

NOTES

Figure 5.26: Review Checklist for Targeting Changes to Influencing Factors

Step 2 - C Documenting Knowledge and Data Gaps

The identification of knowledge and data gaps should be ongoing throughout the entire Level 2 planning process. At its conclusion, managers should have developed a list of gaps that can be incorporated into a Monitoring and Assessment Strategy. **Section 7.0** provides additional guidance on assessment tools and strategies to support the development of these strategies. Because an existing baseline of data and information does not exist for many influencing factors, Level 2 knowledge and data gaps are likely to be significant. Critical gaps must be addressed to ensure that they are resolved over time.

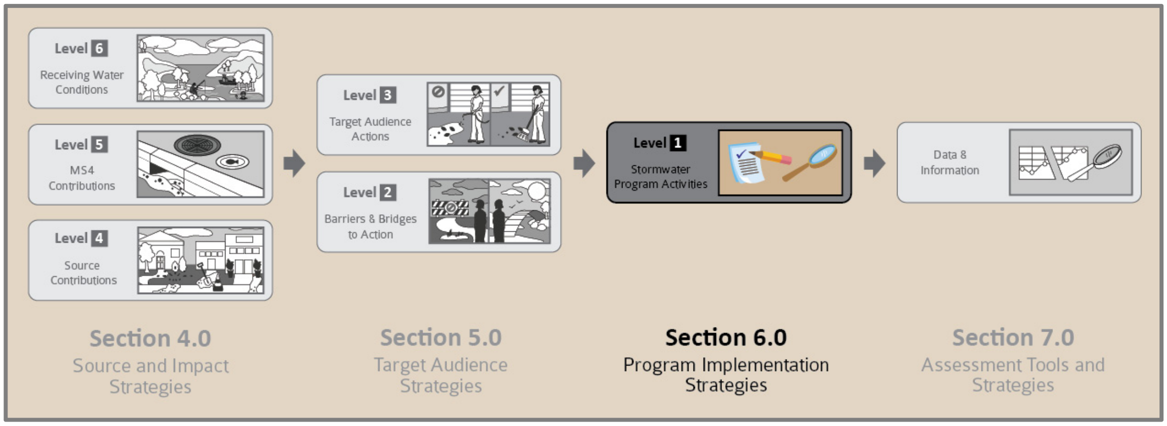
Table 5.19 provides examples of general areas of inquiry where Level 2 knowledge and data gaps are likely to be encountered. These are intended to provide a framework for identifying actual knowledge and data gaps, which will be much more specific than those listed here.

Table 5.19: Potential Areas of Influencing Factor Knowledge and Data Gaps

✓ Understanding of potential influencing factors (nature, magnitude, prevalence, distribution, variability, and trends)
✓ Availability and adequacy of data (sample size, representative sampling, etc.)
✓ Knowledge of regulatory requirements and constraints
✓ Knowledge of economic factors
✓ Knowledge of social factors
✓ Methodologies, criteria, and data support for conducting problem identification
✓ Methodologies, criteria, and data support for prioritization

This page intentionally left blank

Section 6.0 Program Implementation Strategies



*This section describes the development of **Program Implementation Strategies**, the third of the four strategic planning components introduced in Section 3.0. Following the completion of Target Audience Strategies as described in Section 5.0, program implementation planning addresses Outcome Level 1. Managers will consider the target audiences, critical behaviors, and barriers and bridges already identified to develop stormwater program implementation strategies for bringing about targeted changes. Other activities needed to support general program operation and to obtain feedback for evaluating success are also considered.*

Completed Program Implementation Strategies will inform the subsequent development of Assessment Tools and Strategies in Section 7.0.

6.1 Background

Stormwater management programs encompass a remarkable variety of activities and initiatives. A typical program employs numerous types of staff such as inspectors, educators, planners, scientists, managers, and hotline operators. Together they implement policies, programs, and procedures to address almost all major sources of stormwater pollution; including construction and development sites, residential areas, municipal operations, and industrial and commercial facilities. Even a very small program must be administered to thousands of people, sites, and sources, with larger programs easily addressing more than a million people. While this broad focus makes sense, the success of MS4 programs ultimately depends on the details, i.e., whether or not individual program elements and activities are resulting in source reductions.

In Sections 4.0 and 5.0, priority water quality issues, sources and target audiences, and behavioral problems were identified. Building on the results of these planning steps, program implementation approaches must now be selected to bring about and sustain identified changes. As shown in **Figure 6.1**, Level 1 planning is a three-step process.

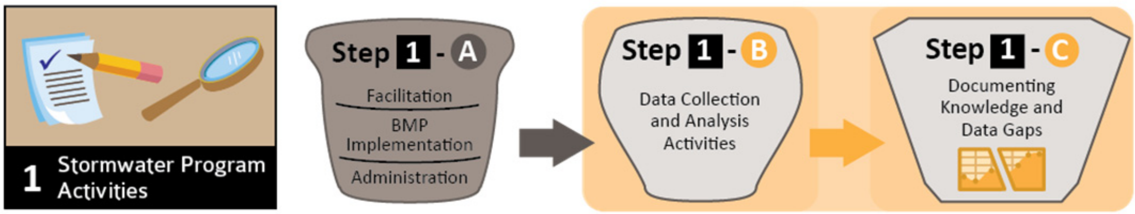


Figure 6.1: Steps for Outcome Level 1 Strategic Planning

In **Step 1-A** managers will identify the activities to be targeted during program implementation. This will initially entail the development of strategies to modify target audience behaviors, but BMPs that can be implemented directly by the stormwater program will also be identified. **Step 1-B** will focus on obtaining the feedback necessary to evaluate these activities. Finally, **Step 1-C** will identify the knowledge and data gaps discovered along the way, so that future data collection initiatives can be directed toward resolving them. Collectively, all of the activities identified in Steps 1-A through 1-C constitute the **Program Implementation Strategy**.

The starting point for Level 1 planning is a review of potential data and information inputs. **Table 6.1** identifies a variety of sources that can be useful. Virtually anything that was part of a previous planning level may be of interest, so reviews should be inclusive at this stage. Likewise, sources not previously reviewed, such as annual compliance reports or permit requirements should also be considered.

6.2 Step 1-A: Program Implementation Activities

Program implementation activities are those which are needed to implement and administer a stormwater management program. Individual activities can serve any of three types of functions:

- Facilitation of behavioral changes in target audiences;
- Direct implementation of treatment control BMPs (retention basins, treatment controls, etc.) by the program; and
- Administration of the program (maintaining source inventories, updating plans, etc.).

Figure 6.2 illustrates these three functions and shows their relationship to each other.

Table 6.1: Potential Inputs for Level 1 Strategic Planning

Previous Outcome Level Results (see Section 5.x)
☑ Priority constituents and stressors
☑ Priority drainage areas and sources
☑ Priority target audiences and characteristics
☑ Identified PGA-BMP packages
☑ Barriers and bridges associated with priority PGAs and BMPs
☑ Outcome Level 2,3,4,5, and 6 knowledge and data gaps
Other Sources and Types of Program Implementation Data and Information (examples only)
☑ Existing compliance reports (annual reports, Reports of Waste Discharge, electronic and hard copy records and documentation, etc.)
☑ Permit requirements
☑ TMDL requirements or implementation plans
☑ Other (as needed)

Step 1-A-(i) Facilitation Activities

Facilitation activities are the means by which programs motivate, empower, or compel target audiences to reduce or eliminate the use of PGAs and increase their use of preferable behaviors. This can include indirect action, such as advocacy for regulatory control ("true source control") by state and federal agencies, including actions affecting product availability to, and use by, target audiences. Collectively these activities constitute **facilitation strategies**. To illustrate, a construction program seeking to increase BMP implementation by site workers might establish a facilitation strategy that includes permitting, inspections, industry training or all three. Or a residential program element might use a combination of mass media education, incentives, and waste collection events to encourage pesticide use reduction and proper disposal. True source control initiatives, such as regulatory restrictions on the amounts of pyrethroids that can be applied in urban areas, can also be important parts of a facilitation strategy. In each case, each identified facilitation activity contributes toward achieving the desired behavioral changes. Because the success of a stormwater program is driven by its ability to influence change, the selection of these activities is one of the most critical decision points in its design.

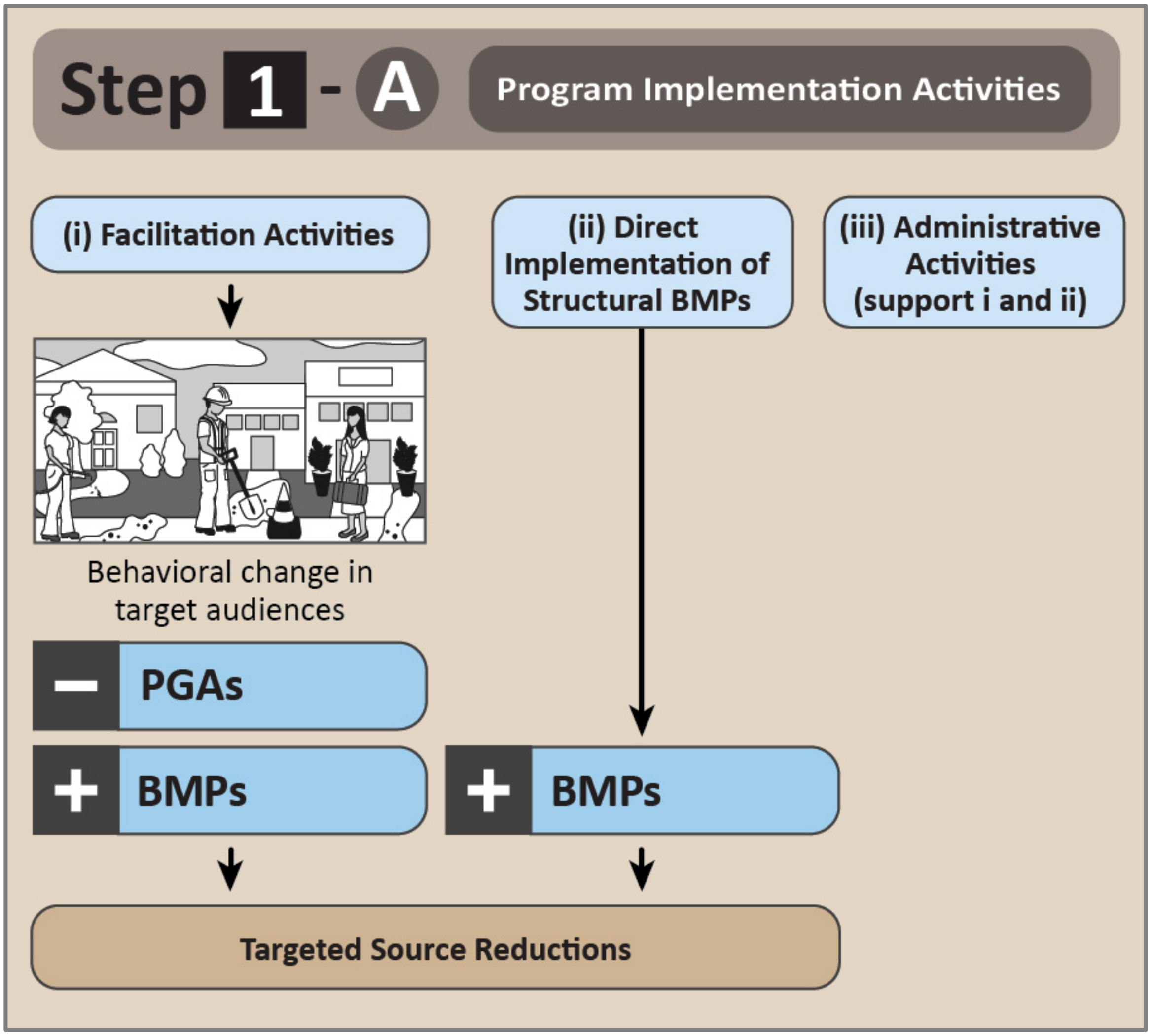


Figure 6.2: The Three Types of Program Implementation Activities

In previous steps, managers identified many of the behaviors associated with priority sources and target audiences, and the key factors that influence them. Focusing specifically on the **PGA-BMP packages** introduced in **Section 5.x**, they will now identify strategies for facilitating shifts in these behavioral patterns away from PGAs and toward BMP implementation.

Types of Facilitation Activities

There are many ways to influence changes in target audiences. In selecting options, it's important to consider the inherent strengths and limitations of each. Activity selection is largely situational, and should reflect the specific characteristics of target audiences and the likelihood of success in influencing or controlling outcomes.

Managers should also keep in mind that many facilitation activities are likely to be implemented concurrently. In accordance with the Strategic Plan Framework introduced in **Section 3.2**, they will normally be grouped according to source categories, source types, target audiences, or other organizing principles utilized by the program. The activities described below provide a good starting point for selecting facilitation activities, but managers should ultimately develop their own lists to suit specific circumstances and planning objectives.

- **Outreach** is a form of education that focuses on providing information, guidance, or assistance to external target audiences. Outreach methods can be used to bring about changes in knowledge, awareness, or behavior. Outreach is often embedded in inspection or other regulatory processes, but may also be approached independently through a variety of means. Examples of outreach types include:
    - Workshops and seminars
    - Community and special events
    - News releases, conferences
    - Presentations
    - Television and radio broadcasts (PSAs, talk shows, etc.)
    - Websites and hotlines
    - Direct mailings, newsletters, and emails
    - Materials displays (billboards, signs, kiosks, movie theatre slides, etc.)
    - Newspaper advertisements, articles, editorials, inserts
    - Consultations, assistance meetings
    - Outreach during inspections

- **Training** is a second form of education focused on teaching the skills or knowledge needed for a particular job or activity. Training can be used to bring about changes in the knowledge, awareness, or behaviors of municipal employees, contractors, and other parties. Topics can vary from general awareness of issues or resources to very specific knowledge of BMPs and other practices. Training may be either formal or informal, and may be presented in a variety of ways (classroom, field, online, etc.).

- **Partnerships** with third parties such as professional and industry organizations, non-governmental organizations, or chambers of commerce can often extend the reach of a program. Partners can support a program's objectives in a number of ways such as developing or printing materials, conducting outreach or training for their members, or organizing clean-up events.

- **Incentives** are activities or initiatives that stimulate an individual or group to act. They can be used to motivate, reward, or recognize individuals or groups for engaging in a particular action. They can take a wide variety of forms, and may apply both to municipal staff and external target audiences. Examples include:

- Employee recognition or time off
- Permit streamlining or fee reductions
- Subsidies for purchasing rain barrels, replacing lawns with drought tolerant landscaping, etc.
- Performance-based certifications (Leadership in Energy and Environmental Design [LEED]; environmental compliance certifications, etc.)

- **Waste collection services** are often provided to assist residents and businesses in properly managing, disposing, or recycling of materials and wastes (e.g., household hazardous waste, used motor oil, or trash). They can include curbside pickup, collection events, or drop-offs at designated locations for a variety of materials or waste streams.

- **Formal agreements** such as contracts with vendors or service providers, leases, covenants, settlements, and maintenance agreements (e.g., for operation and maintenance of structural controls) are often used to require contractors or other regulated parties to implement required control measures.

- **Licenses or permits** can be used to require regulated parties to implement required control measures. Examples include local business licenses, building and grading permits, and special use or event permits.

- **Planning conditions** are used by governments to manage the development of land within their jurisdictions. Planning restrictions typically apply where permissions are needed to build on or change the use of land. In doing so, a jurisdiction can anticipate potential water quality impacts and establish conditions to avoid or mitigate them. Examples include zoning restrictions, smart growth practices, and mitigation requirements for development projects.

- **Corrective actions** such as formal or informal enforcement actions can be used to require a return to compliance with applicable requirements, e.g., during complaint investigations. In some cases, a program may also directly intervene to make corrections or repairs. Within a jurisdiction, disciplinary actions may serve an analogous role for municipal staff.

- **True Source Control** regulatory actions put constraints on the availability or use of products. Many times, they are not implemented directly by programs; instead program staff advocate for the adoption of measures by state or federal agencies. For example, changes to brake pad formulations through the adoption of SB 346, and the adoption of Surface Water Protection Regulations by the Department of Pesticide Regulation. Examples of true source control actions that can be initiated locally are banning the use of plastic bags or Styrofoam cups, or restricting their use at beaches.

Many **other actions** are possible. This list provides a starting point, but it's important that managers continue to identify and explore other options.

Selecting Facilitation Activities

The selection of facilitation activities begins with a review the PGA-BMP packages identified for each target audience. An important input will be the **List of Targeted Changes to Barriers** identified in Step 1-A. In selecting specific activities, it’s important to consider which higher level outcomes they’ll be directed to. Two potential scenarios for the selection of facilitation activities are explored below.

Scenario 1 Directing Facilitation Activities to Barriers or Bridges (Level 2 Outcomes)

Figure 6.3 illustrates a PGA-BMP package with application of currently registered insecticides for ant control as the PGA, and three identified BMP options. Focusing on BMP Option 1 (Use Less Toxic Products), four potential barriers to change were identified. One of these, a lack of knowledge in the target audience, is considered further. Education (either through outreach or training) and enforcement are indicated as potential facilitation activities that are relevant to knowledge levels in the target audience. Based on this, specific educational initiatives such as radio advertisements, newspaper articles, or local workshops could be developed to increase knowledge about the environmental benefits of alternative products (along with other potential topics). Increased enforcement could also be considered, but most programs would probably first start with education.

In this case, directing education specifically to knowledge of the BMP alternative appears to provide managers the best chance of achieving positive results. A critical assumption is that existing levels of knowledge are actually low, and that this is contributing to the absence of the BMP alternative. Ideally, this conclusion would be based on documentation or analysis such as surveys of residents or interviews with compliance staff. In many cases, however, it may just be an educated guess. In both instances, though, a verifiable relationship has been posited between two variables. This relationship can be further evaluated by continuing to implement and document, or through other focused investigations. This might be as simple as using a pre- and post-survey or other follow up measures to check in with the target audience and determine if the program activities are having the desired effect.

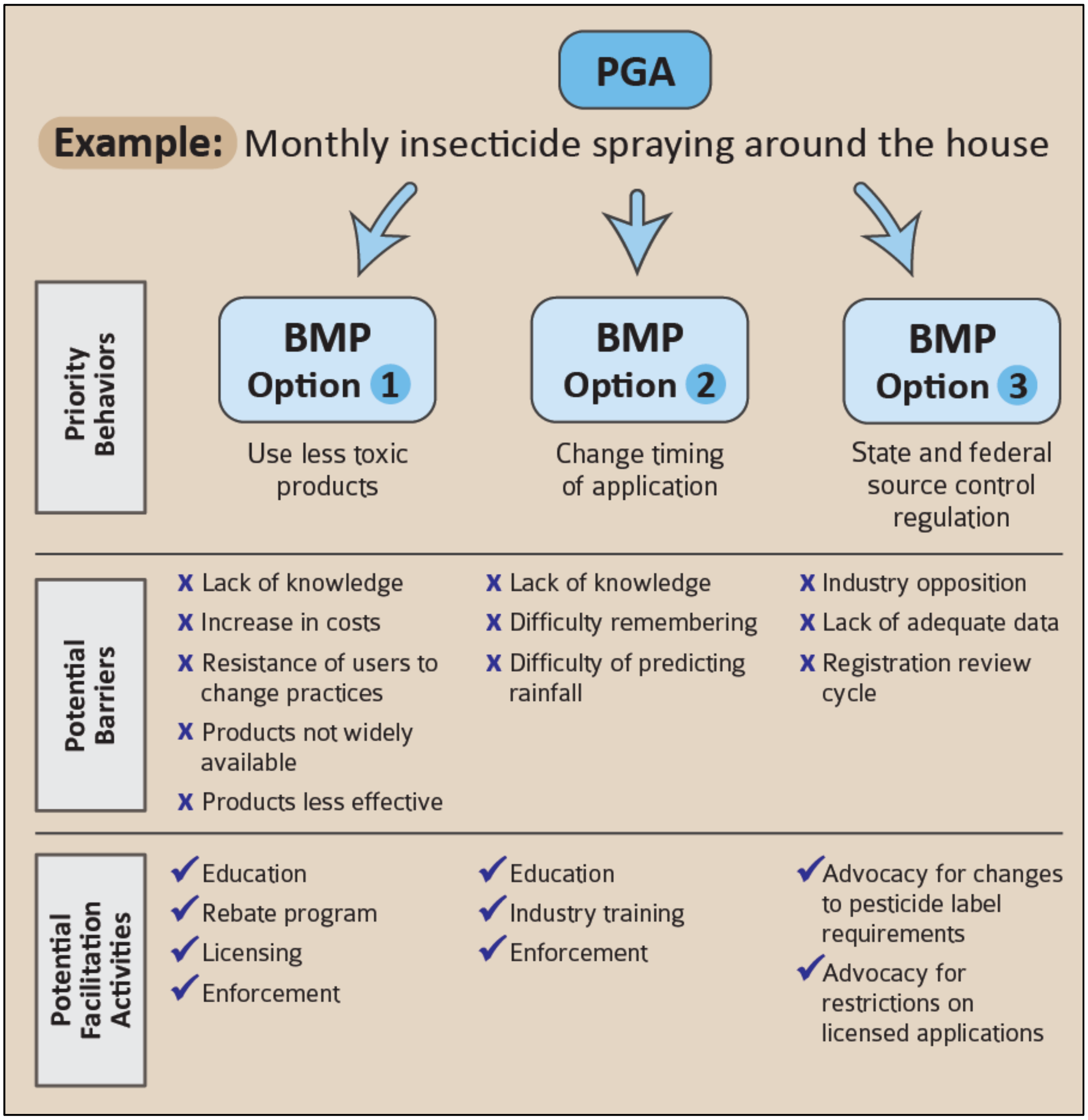


Figure 6.3 Example of Potential Facilitation Activities Associated with a PGA-BMP Package

Further analysis of Options 1 and 2, both of which involve education of pesticide users, should consider the number of pesticide users who could be expected to reduce their use of pesticides beyond the legal restrictions imposed by EPA, and the aggregate reduction that would result. If too few are willing to alter their behavior, even though positive results may be achieved, the aggregate reductions may not be sufficient to solve the problem of pesticide toxicity in the water body.

Where end-user education is unlikely to be sufficient, other options should be considered. Option 3 is an example of influencing change indirectly control through advocacy of regulatory restrictions on pesticide use, e.g., through the California Department of Pesticide Regulation or the USEPA.

Targeting activities to influencing factors is clearly preferred in any instance where they are reasonably well-understood. Ideally managers will know both the specific behavioral changes they want to see and the barriers and bridges that must be addressed to achieve them. In this case, facilitation activities will be directed toward reducing specific barriers or building specific bridges. Normally this would result in one of the three scenarios illustrated in **Figure 6.4**. In practice relationships between facilitation activities and influencing factors often aren't known or well-characterized, and it can be challenging to define them. This should not be a discouragement. Hypothesizing and exploring potential causal relationships is a necessary part of any management approach.

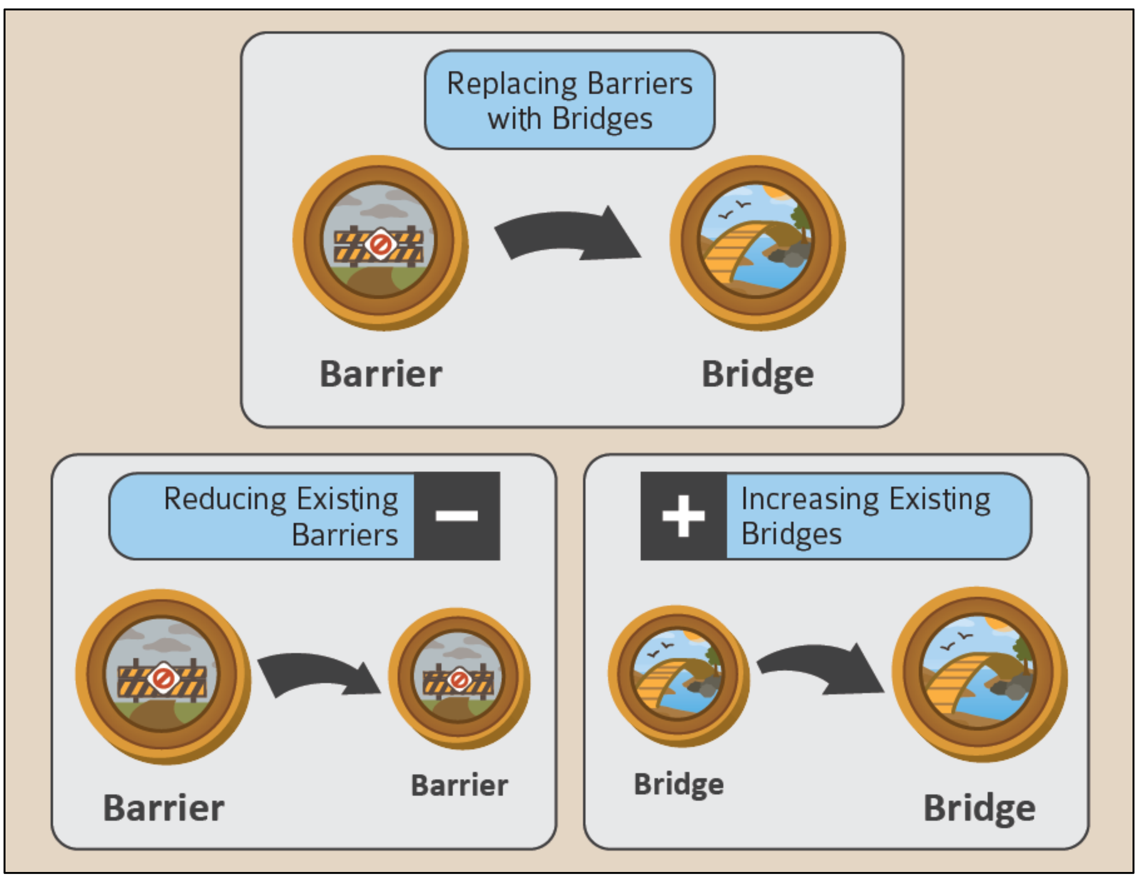


Figure 6.4: The General Ways that Facilitation Activities Act on Influencing Factors

Scenario 2 Directing Facilitation Activities to Behaviors (Level 3 Outcomes)

In many cases, managers will know the behavioral changes they want to see, but won't know which barriers or bridges are influencing them. Unless these relationships can be established, there may be little choice but to direct facilitation activities to the behavior instead.

This time using a different PGA-BMP example, installing smart irrigation systems is identified as a BMP alternative to overwatering, but barriers and bridges have not been identified. Although a number of potential reasons might exist, it's entirely possible that managers would have no specific idea of why some people choose not to install the systems. Without an idea of what these potential barriers or bridges are, it's difficult to know how to direct facilitation activities. Assuming that implementation can't always be delayed until influencing factors are better understood, managers must use best professional judgment in selecting and implementing a reasonable set of facilitation activities that can be implemented "experimentally." That is, by committing to specific facilitation activities, implementing them, and monitoring their success in bringing about desired behavioral changes. This "trial and error" approach may be perfectly reasonable where barriers and bridges are unknown or difficult to characterize, or where programs are not resourced to invest in their characterization.

In the absence of specific knowledge, some caution should be exercised in making commitments. Educational approaches are normally a good starting point because knowledge and awareness are often found to be lacking. If increases in knowledge or awareness are achieved, and not found to bring about targeted behavioral changes, managers can move on to other potential barriers or bridges. Managers should always seek to understand the role of applicable influencing factors, but this is not to say that behavioral changes achieved without this understanding aren't successes in their own right. Ultimately, it's the behavioral changes that count, and managers should choose the approaches that work best for them.

Setting Implementation Targets for Facilitation Activities

Once facilitation activities have been selected, managers will need to establish implementation targets for each of them. It can often be quite challenging to determine what levels are appropriate or achievable. Potential approaches for setting targets are described below. Given the variety of potential activities, and the need to consider the specific context of their application, there is no simple formula for targeting facilitation activities. Regardless of which approaches are chosen, managers are reminded that multiple facilitation activities are normally directed to a particular behavior or influencing factor. Because the most important consideration in targeting is the cumulative impact of all the activities within the facilitation strategy, targeting should also recognize that pollutant load reduction goals might be achievable with less than maximum BMP implementation or total elimination of all PGAs. Since "successes" and "failures" are likely to offset each other, it's important that implementation targets remain flexible and be adjusted as necessary to accommodate this fluidity.

Setting Targets to Comply with Regulatory Requirements

Regulatory requirements, particularly those established in permits and TMDLs, should always be considered up front. These requirements may be explicit (e.g., minimum inspection frequencies) or implicit (e.g., levels of outreach or enforcement needed to achieve required reductions in dry weather discharges). Because they are legally enforceable, regulatory requirements may sometimes override other potential targets. As previously described, managers must remain compliant with legal and regulatory obligations, but may also need to advocate for flexibility or regulatory change when they present conflicts.

Setting Targets to Achieve Specific Level 2 or 3 changes

This should be the preferred approach when targets have been defined for the higher outcome level changes, and their relationship to the facilitation activity is quantifiable. Since the magnitude of the Level 2 or 3 outcomes is assumed to be a function of the magnitude of the facilitation activity (or activities), a change in one should cause a corresponding change in the other. In this instance, the facilitation activity target will be set to the specific quantifiable change it is expected to bring about in the Level 2 or 3 outcome. Ideally both endpoints are known and quantifiable. Where they are not, relationships between them can still be explored "experimentally" as described below.

Setting Targets to Resource Availability

These considerations are often necessary because programs don't always have the staffing, budget, or other resources needed to pursue targets established through other approaches. Where possible, managers are always encouraged to optimize the allocation of available resources rather than assuming that a target is resource-limited. Moreover, it's important to remember that targets which are too low may not be effective. Rather than under-targeting because of resource limitations, it may make more sense to defer the implementation of some activities until additional resources can be obtained, or to divert those existing resources to another priority problem.

Setting Targets to Learn and Adapt

Although managers usually have a good idea of the levels of program activity they can achieve within defined resource commitments, they don't usually know what it takes to bring about specific changes in target audience behaviors. In some cases, it just makes sense to establish targets for the purpose of learning. By "dialing" a particular activity up or down, managers can explore implications of that action over time. One way is to set **stretch targets**, which involves increasing a particular activity over a previous level. This is a simple way of testing what can be cost–effectively accomplished.

Experimental targets are similar to stretch targets, but are instead intended to explore and test assumptions or hypotheses about relationships between outcomes. If managers have a good idea of the types and levels of activities that can be directed to a target audience, they might establish a working hypothesis about the behavioral changes they hope to see in them. By establishing and tracking measurements for both types of outcomes, they may be able to establish linkages over time.

Step 1-A-(ii) Direct Implementation of Treatment Control BMPs by MS4 Programs

Another important type of implementation activity is the **direct implementation of treatment control BMPs** by the MS4 program. The purpose of this step is simply to ensure the consideration of these BMPs in the overall Program Implementation Strategy. Given the increasingly stringent performance expectations put on MS4 programs in recent years, both for permit and TMDL requirements, emphasis on the direct implementation of structural treatment controls has also increased. Traditionally, a number of other BMP types (street sweeping, MS4 cleaning, waste collection, etc) are implemented by municipalities. These BMPs are not included in this category because they're already addressed as municipal operations under facilitated activities above[1].

[1] A critical difference between direct implementation and the activities described in Step 1-A(i) is the absence of a separate target audience to which facilitation activities are directed. This category addresses only structural controls implemented directly by the MS4 program, and because it assumes direct implementation, facilitation is unnecessary. Because there is no consistent division between MS4 program staff and other municipal staff within municipalities, some managers may find that the activities described

Many programs are also now planning and funding the construction and maintenance of regional or sub-regional treatment control BMPs. Because MS4 programs exert a much higher degree of control over the construction and long-term maintenance of these BMPs than for those implemented by external target audiences, they can critical to successful implementation strategy.

Normally there should be a greater ability to forecast the potential benefits of directly-implemented BMPs than those facilitated through target audiences. Setting targets for BMP performance should be approached by first allocating a portion of the desired loading reductions within a defined drainage area to MS4 structural BMPs. Together with other reductions projected for facilitated target audiences, this should constitute the overall targeted reductions for the drainage area. Portions of the structural BMP allocation can then be divided over all potential or planned structural BMPs for that area. Given that each structural BMP is built to specific design and performance standards, this process should be straightforward.

Selection, sizing, and location of specific BMPs will reflect a variety of considerations, including pollutants of concern, wet and dry weather targets, design and construction costs, experience with the BMP type, community support, and maintenance responsibilities and costs.

Step 1-A-(iii) Administrative Activities

Administrative activities support the effective operation and management of the stormwater program. They focus on the operation of the program itself rather than its relationship to target audiences or direct BMP implementation. Examples include reviewing and updating source inventories and program documentation such as policies or procedures. Many administrative activities are explicitly required by stormwater permits, and must therefore be assessed and reported to maintain regulatory compliance; others are implicitly required, or simply necessary to assure the ongoing implementation of the program. It's important that they be identified as part of the larger Program Implementation Strategy because they're necessary to ensure that essential functions are completed or supported. **Table 6.2** identifies some general categories and examples of administration activities.

---

here actually apply to municipal staffs that are considered target audiences. Where the line is drawn is less critical than that each activity type is given due consideration.

Table 6.2 Examples of Administrative Activities

Administrative Activity Type	Description
Program Plan Updates	Various strategic and operational plans define Stormwater Management Program control strategies and guide their implementation. Depending on the permit requirements, a program may have one or more plans associated with it. Periodic reviews and updates of these plans are necessary to ensure they remain current and reflective of regulatory requirements.
Source Inventory Updates	Inventories of commercial businesses, construction sites, and other sources must be developed and maintained. Individual or categorical source priorities must also be established and updated as necessary.
Legal Authority Updates	Ordinances, codes, and other legal authorities must be established and periodically updated to enable enforcement of program requirements.
Supporting Program Documentation Updates	Policies, procedures, guidelines, forms, and various other types of program documentation are necessary to support program implementation. Periodic reviews and updates are necessary to ensure they remain current and reflective of regulatory requirements.

6.3 Step 1-B Data Collection and Analysis Activities

Data collection and analysis activities provide managers the feedback necessary to assess conditions, evaluate changes, and determine whether specific objectives are being achieved. The purpose of this step is simply to ensure that managers have anticipated data collection and analysis in the design of their Program Implementation Strategies. Analysis of data and information will be considered further in **Section 7.0**.

There are a number of ways in which the data needed for planning and assessing stormwater programs can be collected. These are illustrated in **Figure 6.5**. **Data collection strategies** should encompass all of the data and information needed to track and evaluate conditions or outcomes identified in Level 1 through 6 planning. Depending on the situation, a number of options may exist for obtaining any desired data and information, each of which has inherent advantages and disadvantages. The selection of activities should reflect the nature and relative importance of the feedback being sought, as well as the ability of the program to effectively and economically obtain the data and information.

These categories are not completely distinct. For instance, site investigations might include direct documentation of observations, or monitoring and sampling by Stormwater

Management Program staff. Any of these activities might also be conducted routinely or as part of special investigations.

Figure 6.5: Types of Data Collection Activities

There are also a number of ways in which the analysis of data collected by stormwater programs can be approached. These are illustrated generally in **Figure 6.6**. Approaches to data analysis are further explored in **Section 7.5**.

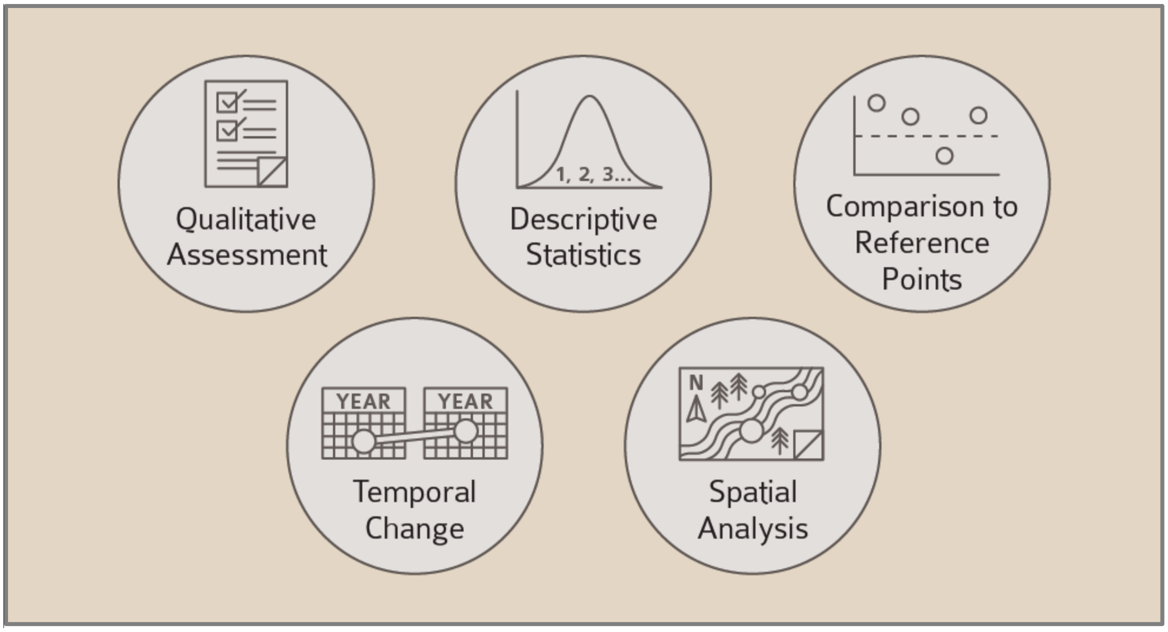


Figure 6.6: Types of Data Analysis Activities

6.4 Sustainability Considerations

Any MS4 Program Implementation Strategy will represent a large commitment of public funds toward the resolution of identified problems. As previously described in **Section 3.0** (**Key Concept 3.5**), stormwater strategic planning should be guided by a balance of environmental, economic, and social considerations. The three critical points in the planning process where this is imperative are the prioritization of problems, the targeting of end-state conditions, and the selection of program implementation strategies.

Up to now, all discussion of Level 1 activity selection has centered on technical considerations, primarily the anticipated benefits of implementation in bringing about behavioral changes and source reductions. Sustainability approaches look beyond technical considerations to guide managers toward priorities and solutions with the best chances of long-term success.

At this point, managers will have developed a provisional list of program implementation activities to be directed to priority target audiences and PGA-BMP packages. Building on these results, they are encouraged to further review their Program Implementation Strategies in the context of the economic feasibility and social acceptance of each proposed activity. This will apply primarily to facilitation activities and direct BMP implementation since these normally constitute the most significant program commitments.

- **Economic factors** are essential because every potential action comes at a cost that must be balanced with the implications of non-action and managers' ability to expend resources. Specific costs may ultimately be borne by the MS4 program, target audiences, or society at large. Questions that may be considered include the following:
  - What are the costs of implementation? Are they one-time or ongoing?
  - Who bears the costs (taxpayers, businesses, permit applicants, etc,)?
  - What is the cost-effectiveness of the proposed action? How do costs compare to benefits? What is the return on investment?
- **Social factors** are those related to society at large or specific segments within it. Perceptions and opinions regarding proposed implementation activities can be important to prioritization. Although the public may often be unaware of many of the details of a MS4 program, they expect to utilize and enjoy receiving waters, and they play a role in the control measures instituted to protect them. It's important to know if specific activities are more or less acceptable to the public, as well whether or not they're directed to issues or problems that are important to the public.

Based on this additional review, managers may or may not conclude that a prioritization of activities within the program implementation strategy is needed.

6.5 Step 1-C: Documenting Knowledge and Data Gaps

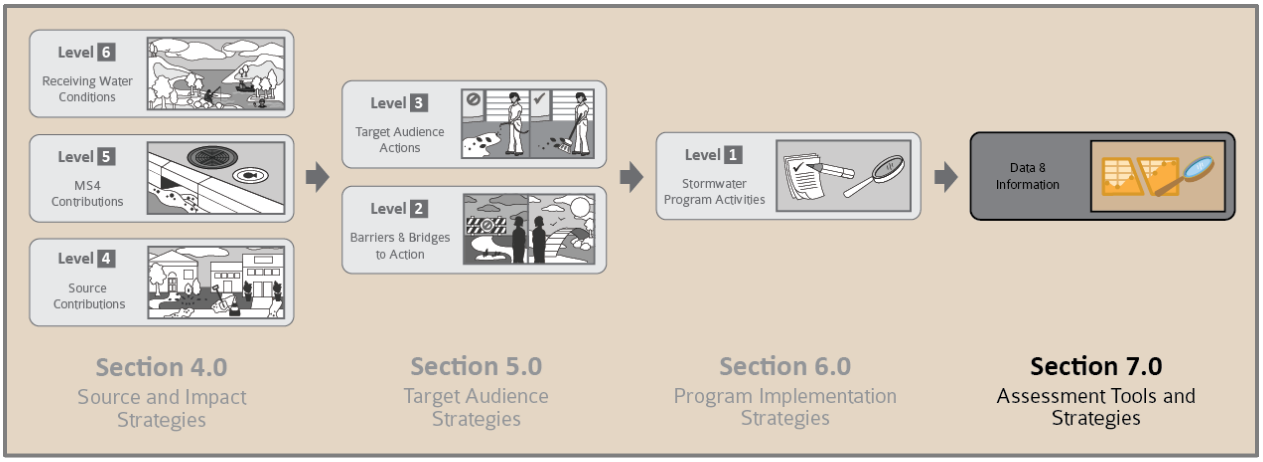
It can often appear that knowledge and data gaps are of less concern for Level 1 than during other planning steps because managers have direct access to much of the program data they need. In some cases this is true, but a significant potential exists for some types of Level 1 gaps.

Critical gaps must be addressed in the development of program implementation strategies to ensure that they are resolved over time. **Table 6.3** provides examples of general areas of inquiry where Level 1 knowledge and data gaps are likely to be encountered. These are intended to provide a framework for identifying actual knowledge and data gaps, which will be much more specific than those listed here.

Table 6.3: Potential Areas of Program Implementation Knowledge and Data Gaps

- ✓ Effectiveness of facilitation activities
- ✓ Effectiveness of treatment controls
- ✓ Costs and cost-effectiveness of potential implementation options (treatment controls, source controls, etc.)
- ✓ Support for facilitation activities
- ✓ Relationship of implementation activities to target audience behaviors
- ✓ Relationship of implementation activities to barriers and bridges
- ✓ Knowledge of incentive-based and other non-traditional approaches
- ✓ Adequacy of documentation of facilitation activities
- ✓ Adequacy of data collection activities (ability to support analysis, etc.)
- ✓ Knowledge of economic and social factors affecting program implementation

Section 7.0 Assessment Tools and Strategies



7.1 Background

This section describes the development of **Assessment Tools and Strategies**, the last of four strategic planning components initially introduced in **Section 3.0**. Up to this point, managers will have focused on a planning process aimed at identifying a variety of specific measurable outcomes to:

- Define success;
- Guide the implementation and evaluation of programs; and
- Provide the structure and measurability needed to support adaptive management.

> ***Assessment Strategy**: The methods and approaches used to collect and analyze data to assess progress in meeting targets. Assessment strategies help identify linkages between outcome levels and data gaps. They are also part of an adaptive management approach that provides ongoing feedback to improve program effectiveness.*

This section provides guidance to assist in developing appropriate metrics and assessment tools to measure progress toward meeting previously defined targets.

The starting point for assessment is the completion of the strategic planning process described in Sections 3.0 through 6.0 of this document. Building on the analytical objectives established in that process, this section provides additional guidance for defining the metrics, monitoring methods, and analytical approaches needed to inform decision-making for each outcome level. As programs are implemented and data obtained, managers may reevaluate how best to measure program progress as they compare new data against established targets.

Section 7.0 builds on the targeted outcomes identified in Sections 4.0 through 6.0 to provide information on the following:

- **Iterative and Adaptive Management:** This section identifies how effectiveness assessment informs the adaptive management process.
- **Assessment Objectives:** This section addresses three assessment objectives that assist managers in determining whether their programs are properly directed and achieving the desired benefits, as well as in identifying what other knowledge and data are needed in order to adaptively manage the program.
- **Data Collection:** This section provides a summary of data resources as well as approaches and methods that can be used to obtain the data that are needed for program assessment.
- **Data Analysis:** This section provides an overview of the approaches that may be used by managers to analyze the assessment data at each outcome level.

7.2 Iterative and Adaptive Management

Effectiveness assessment is the mechanism by which feedback is evaluated to enable ongoing adaptive management. First introduced in **Section 3.0**, the iterative program management cycle (**Figure 7.1**) consists of program planning and modification, program implementation, and effectiveness assessment. Over time, the repeated application of this process – each phase continuously informing the next – should result in the improvement of stormwater programs and the achievement of the desired results.

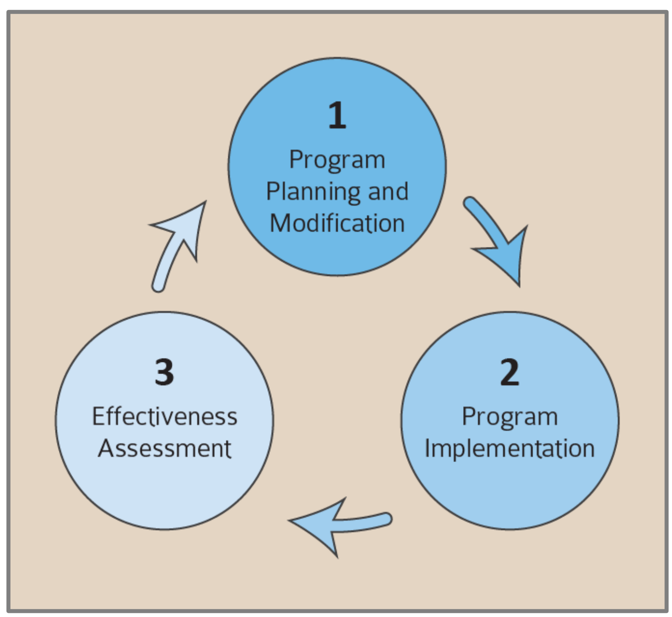


Figure 7.1: The Iterative Program Management Cycle

An iterative and adaptive management process uses the results of the effectiveness assessments to modify and improve management measures to more effectively meet the interim and end-state targets. This may include addressing data gaps to reassess assumptions that were used in developing the priorities, targets, and management measures. Adaptive management may also include the application of "lessons learned" to steer the program in new directions.

As program implementation proceeds, data gathered from the various activities should be assessed to evaluate and refine the critical assumptions as well as the approach and /or schedule for subsequent implementation measures.

Because adaptive management is critical to ensuring that stormwater programs are effective in achieving long-term goals, a manager should ensure that permit requirements provide the flexibility to adaptively manage the program. A recent trend in MS4 permit reissuance is to incorporate specific adaptive management measures to support the improvement of the programs. On a practical level, it is important to ensure that the permit provisions provide the flexibility to adaptively manage the program. This is something that might be considered during the development of the Report of Waste Discharge and during permit renewal.

7.3 Assessment Objectives

This section describes the following program assessment objectives:

- Program Planning Evaluation and Refinement,
- Evaluation of Success, and
- Evaluation and Resolution of Knowledge and Data Gaps.

This section also presents assessment approaches for different outcome levels (e.g., MS4 discharge quality, source contributions to pollutant loading, and behavior changes) and provides examples.

7.3.1 Program Planning Evaluation and Refinement

Managers must assess whether a program is being effectively implemented and progressing toward the attainment of the goals. In other words, it is critical to understand if the program is effectively addressing the issues that it is intending to address.

As a first step, targeted outcomes should be established as described in Sections 3.0 through 6.0. It is preferable if managers have a specific idea as to what they want to achieve, as well as the data that are necessary to evaluate each outcome. However, managers should also be mindful of the challenges associated with the establishment and interpretation of these targeted outcomes.

In cases where a clear understanding of what can or should be achieved does not exist, it may be necessary to track results over time to determine feasible, appropriate, and worthwhile outcomes. Moreover, targeted outcomes must often be considered to be provisional, intended to illuminate a *direction* rather than to define an *endpoint*. As such, they are best understood as interim measures designed to support the iterative program management process, rather than as absolute representations of success.

Management questions form the basis for the types of data that must be gathered and evaluated. The types of questions that may be formulated include evaluating relationships of data between outcome levels and/or in relation to geospatial area, land use, targeted audience, or time interval. For example, defining or verifying the relationship between the volume of trash measured at targeted MS4 outfalls adjacent to an area subject to a targeted trash reduction outreach program may serve as a measure of program effectiveness.

Deciding where to set the targeted outcomes is often one of the most challenging aspects of stormwater management. The level of effort, performance, or change that constitutes a positive result is rarely obvious. Moreover, it can be difficult to relate individual assessment measures to each other or to longer-term goals for improving receiving water quality. When defining a targeted outcome, several elements should be considered (**Table 7.1**).

Table 7.1: General Elements to Consider in Establishing Targeted Outcomes

Element	Example(s)
• The **direction** of the change	• Increase or decrease
• The **nature** of the outcome	• Hotline calls received, chemical concentration
• The **metric** (magnitude + unit) of the change	• 20 people, 50%, 3.0 mg/L, 30 lbs.
• The **reference point** from which change is measured	• Existing or baseline levels, previous results, results at another location
• The **timeframe** for achieving the change. This can include time elapsed or a **period of time**.	• Hours, days, months, years, reporting period, permit cycle.

When crafting a targeted outcome statement, it is suggested that managers begin with a general outcome statement, and then add specificity and units of measurement, as follows:

[DIRECTION] [NATURE] by [METRIC] over [REFERENCE POINT] by [TIMEFRAME]

Two examples of targeted outcome statements are provided below. These examples are for illustration only. There is no single template for targeting outcomes that applies in all instances.

Example 1

General Outcome Statement:

Decrease copper levels in the San Diego River

Add Specificity and Units of Measurement:

[DIRECTION Decrease] [NATURE receiving water concentrations of copper] by [MAGNITUDE / UNIT OF MEASUREMENT 3.0 mg/L] from [REFERENCE POINT June 2011 levels] by [TIMEFRAME March 2025]

Result:

Decrease receiving water concentrations of copper by 3.0 mg/L from June 2011 levels by March 2025.

Example 2

General Outcome Statement:

Increase awareness of the residential sector

Add Specificity and Units of Measurement:

[DIRECTION Increase] [NATURE, hotline calls, website reports, referrals] by [MAGNITUDE / UNIT OF MEASUREMENT number or %] over [REFERENCE POINT baseline, existing levels] by [TIMEFRAME reporting period]

Result:

Increase the number or % of hotline calls, website reports, and referrals over baseline, existing levels by the end of the reporting period.

7.3.2 Evaluation of Success

For programs to succeed, managers must have the tools to determine if the targeted outcomes set for the program are being achieved. In addition, managers need to know how efficient the program was in meeting those goals.

This step focuses on evaluation of *assessment results* using the targeted outcomes and associated metrics established during the planning process. Metrics need to be developed to assure that an assessment can be made in order to track progress in meeting the target. For example, a metric to measure progress toward a target of a 50% reduction in a pollutant load needs to include the measurement of flows and concentrations over a representative time period, which can then be compared to a baseline load in order to establish a percent reduction in load.

The use of targeted outcomes in interpreting results of assessment data and measuring success can be represented as follows:

$$\left(\frac{Actual\ Outcome}{Targeted\ Outcome}\right) = \ Assessment\ Result$$

Where:

- The Actual Outcome is a measured condition or implementation result;
- The Targeted Outcome is a value established during planning to define adequacy or success (interim or final); and
- The Assessment Result describes the relationship of the Actual and Targeted Outcomes and in doing so ties the planning and assessment processes together.

Example

During planning, a goal of inspecting all of the 125 facilities in an industrial facility inventory is set. At the end of the year, 100 initial inspections have actually been conducted, representing an 80% success rate.

$$\left(\frac{100\ inspections\ conducted}{125\ inspections\ targeted}\right) = 80\%\ success$$

Considered in this way, targeted outcomes are requisite for the planning of an assessment approach and the interpretation of results. Without them, outcomes do not have a context and can only be reported or described. In practice, the analysis of outcomes involves a variety of approaches, all of which build on this fundamental relationship of actual and targeted values.

Examples of outcome types, interim targets, metrics, and assessment results are provided in **Tables 7.2** through **7.6**. *These examples are provided as guidance and do not represent program requirements. Each program will have its specific requirements depending on factors such as regulatory requirements, program priorities, and available resources.*

Table 7.2: Outcome Level 6: Receiving Water Conditions – Example Outcome Types, Targets, and Metrics and Assessment Results

Example Outcome Types	Example Targets	Example Metrics	Assessment Result = Actual vs. Target
Chemical – Water Quality Priority Problems			
Receiving Water Quality - Average constituent concentrations Constituent concentrations during wet weather	Reduce constituent concentration to WQ benchmark Reduce average daily constituent concentration to a specified percentage above WQ Benchmarks.	Water Quality Benchmark concentration in µg/L % change in loading or concentration compared to previous year's results	Measured constituent concentration as percentage of benchmark or reference system condition Estimated % pollutant loading change
Physical Priority Problems			
Hydromodifcation Peak flow measurements compared to reference site condition	Reduce peak flow volumes by X% in impacted stream segments.	Flow Volume and Peak Flow - change in trend toward reduced peak flows for specific storm events Flow Volume and Peak Flow - % reductions in peak flow toward end-state target based on allowable velocities and peak flows for impacted stream	Measured % reduction in peak and total flow Measured condition versus pre-conditions or interim target
Biological Priority Problems			
Beneficial Use Protection – Bio-indicators (benthic impairment in creek)	Achieve a specific bioassessment rating or a value comparable to reference site conditions	Measured IBI ratings	IBI rating for reporting period compared to target or applicable reference site conditions

Table 7.3: Outcome Level 5: MS4 Contributions - Example Outcome Types, Targets, and Metrics and Assessment Results

Example Outcome Types	Example Targets	Example Metrics	Assessment Result = Actual vs. Target
Chemical – Water Quality Priority Problems			
Urban Runoff Quality: Constituent concentration during wet weather in MS4 Outfalls	Reduce constituent concentration to certain % below Action Level in Targeted MS4 Outfalls. Reduce annual loading by specified percentage compared to previous reporting period.	Constituent concentration in µg/L Specified % change in estimated annual loading	Measured constituent concentration compared to Action Level % reduction compared to % reduction targeted or Action Level
Physical Priority Problems			
Urban Runoff Hydrology: Peak flow and flow volumes at MS4 Outfalls	Reduce peak flow volumes by X% in targeted MS4 outfalls.	Flow volume and peak flow in CFS % reductions in peak flow toward end-state target based on allowable velocities and peak flows for impacted stream	% reduction in peak and total flow toward pre-conditions compared to % reductions of Interim Target % of MS4 outfalls that meet target compared to % of Interim Target

Table 7.4: Outcome Level 4: Source Contributions - Example Outcome Types, Targets, and Metrics and Assessment Results

Example Outcome Types	Example Targets	Example Metrics	Assessment Results = Actual vs. Target
Example: Construction Sites			
Source Pollutant Loads: Inspection and enforcement data indicates sites that are sources of sediment	Reduce loads from construction site sources of sediment by certain % in one year.	Quantity of sediment that diverted from MS4	Estimated reduction in sediment released into MS4
	Achieve specified % of construction sites that have properly implemented erosion control BMPs (indirect measure of loading).	Number of Construction sites properly implementing BMPs	% of construction sites that have properly implemented erosion control BMPs compared to established interim or end-state target
Example: Over-Irrigation (Residential and Commercial Properties)			
Site Source Hydrology and Source Pollutant Loads: Over-irrigation in residential land uses and commercial properties that are landscaped results in dry weather flows to MS4	Reduce dry weather runoff observed at MS4 outfalls by specified % in one reporting period.	Average 24 Hour Flow volume (cubic feet) at MS4 Outfalls during dry weather months Estimated volume of irrigation runoff based on observation during inspections of targeted residential areas and commercial properties	% reduction in volume of flow from over-irrigation from residences and commercial properties compared to interim target within targeted drainage areas

Table 7.5: Outcome Level 3: Target Audience Actions - Example Targets and Metrics and Assessment Results

Example Targets	Example Metrics	Assessment Results = Actual vs. Target
Informational Requests		
Increase number or % construction companies who have correct information on construction requirements	No. of hotline calls from construction companies requesting information on construction requirements in 1 year	Number of calls received compared to number or % of Interim Target
Pollution Reporting		
Increase no. of callers reporting construction site violations	No. of reported construction site violations Number of confirmed violations based on hotline calls	% of all calls received that are related to a confirmed violation compared to Interim Target
Public Participation/Involvement		
Increase number or % of contractors who are knowledgeable regarding SWPPP preparation and implementation	No. or % of contractors participating in in SWPPP training in one year	% of contractors participating in SWPPP training compared to Interim Target
Administrative and Procedural Behaviors		
Increase number or % of sites with approved SWPPPs	No. of sites with approved SWPPPs or other required documentation based on site inspections	No. of sites with approved SWPPPs or other required documentation compared to interim target
Illicit Discharge Control		
Decrease number or % of sites with illicit discharges	No. of sites without observed discharge violations based on site inspections	No. of sites with fewer observed discharge violations compared to previous inspection
Reduce frequency of over-irrigation from residences	No. of landscape conversions and installations of smart irrigation systems in one dry weather season	% increase in the number of turf conversions by and installation of smart irrigation compared to previous year and Interim Target
BMP Implementation		
Achieve properly implementation of BMPs to reduce runoff	Number of sites where BMPs implemented in accordance with approved SWPPP based on site inspections	Increase in number of sites where BMPs are implemented in accordance with approved SWPPP compared to initial inspection results

Table 7.6: Outcome Level 2: Barriers and Bridges to Action - Example Outcome Types, Targets, and Metrics and Assessment Results (Personal Factors only)

Example Outcome Types	Example Targets	Example Metrics	Assessment Results = Actual vs. Target
PROGRAM COMPONENT / ELEMENT: Construction [Private]			
TARGET AUDIENCE: Construction Projects / Proponents			
1. **AWARENESS OF PROGRAM RESOURCES**	Increase number or % of current target audience know how to report illicit discharges.	Number of calls to storm water hotline to report violations or illicit discharges	Number of calls to storm water hotline to report violations compared to total number of calls Increase in calls reporting violation compared to previous year
2. **KNOWLEDGE OF GENERAL OR SPECIFIC CONCEPTS**	Increase number or % of target audience aware of the difference between the storm drain and sanitary sewer.	% of survey respondents responding correctly to questions regarding difference between the storm drain and sanitary sewer	% of correct responses compared to target
	Increase number or % of construction staff that know about impacts of construction on waterways.	Number of construction staff that have attended training and ranked it effective	Actual % of construction staff that have ranked it effective compared to interim target
3. **ATTITUDES**	Increase number or % of construction staff that believe implementation of BMPs helps the environment.	Number of construction staff responding to a post-training survey that implementation of BMPs will prevent pollutants from reaching waterways	% of construction staff responses from post-training survey compared to pre-training survey

7.3.3 Evaluation and Resolution of Knowledge and Data Gaps

At this step in the process, it may evident that a program does not have all of the information it needs in order to conduct the assessment. Determining which of these data or information gaps are the most important will help to guide the future assessments.

Identification of knowledge and data gaps should be ongoing throughout the planning process at each Outcome Level. At its conclusion, managers should have developed a list of gaps that can be incorporated into the overall assessment strategy. As discussed in previous sections, clearly defining the problem and establishing a targeted outcome will often result in identifying aspects of the problem where more information is needed. This could include better quantification of sources, characterization of the target audience, or determination of local restrictions that need to be addressed before putting a new program in place.

Addressing data gaps found during the planning process by finding new data sources, alternate solutions, or ways to address the gaps will help to improve a program's ability to meet the targeted outcomes. As data gaps are addressed, the original basis used to set these metrics, targets, and control measures may change; therefore, corresponding modifications may need to be made to these components, as well as to the program itself.

7.4 Data Collection

Depending on the implementation activity, program and/or goals, a variety of data collection approaches and methods may be appropriate. It is recommended that managers consider a broad spectrum of targeted outcomes, programmatic outcomes, and/or data gap resolution goals when selecting appropriate data collection methods. **Table 7.7** provides examples of data collection approaches and methods that can be used as a basis for identifying and developing the data collection activities for your program. **Table 7.8** presents the general applicability of these data collection method approaches to the different outcome levels. In addition, several examples of and information resources are listed in **Table 7.9**. More information on data and information resources is provided in Section 4.0 through 6.0.

Table 7.7: General Approaches to Data Collection

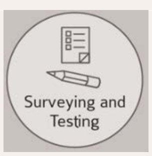
Approach	Description
	Internal tracking and evaluation of data is the primary means by which Level 1 activities can be assessed. Internal program data; inspection data, outreach conducted, etc.
	Various types of program data or information may be reported to the stormwater program either by regulated parties or other municipal staff that are not part of the stormwater program. In some instances regulated parties must periodically certify compliance with specific requirements (e.g., maintenance of structural treatment controls). Third parties; BMP maintenance certifications, industrial facility monitoring data, correction of violations, etc.
	Site inspections and audits are among of the most common tools used to verify compliance or gather additional data. Inspections typically consist of observations, record reviews, and sampling as needed. For example, does the target audience, in this case a facility operator understand what is required to comply with the storm water program, does the understanding lead the effective implementation of BMPs that will lead to reductions in pollutant loading. Complaint investigations are similar to site inspections except that they are in response to reports of potential violations (e.g., through or complaints or staff referrals) but can provide insight into public awareness and reach of program messaging.
	Interviews may be completed by municipal staff, facility staff or third party contractor. Interviews can be structured with specific questions or in response to inspection results, and are an essential piece of site audits as well as complaint responses. They are a useful tool for gauging awareness and BMP compliance understanding.
	Surveys, tests, and quizzes are generally focused on entire populations (e.g., all residents) or sub-populations (e.g., used oil recyclers), and tests and quizzes administered to individuals (e.g., municipal staff or schoolchildren). They are fundamentally different in that surveys generally focus on understanding the prevalence or distribution of attitudes, knowledge, or behaviors within a population, whereas tests and quizzes focus on “correct” knowledge”, i.e., respondents’ understanding of specific facts.
	Monitoring or sampling of runoff and receiving water quality may occur as part of routine programs or in response to audits or complaints. Sampling may be focused on MS4 discharges, receiving waters, or the sources discharging to them.
	Data may also be obtained from outside sources that can be used for assessment purposes. When using third party and outside data, data quality should be considered. Data of similar or higher quality should be used in making quantitative assessments.
	Special Studies may be part of a requirement in a MS4 permit or Investigation Order by the Regional Board to address specific data requirements for a TMDL or in response to historical receiving water and/or MS4 outfall data. Special studies may also include source identification studies in cooperation with other stakeholder for priority constituents or potential sources. Special Investigations can encompass any of the categories above, but generally tend to be a more intensive question- or project-driven focus.

Table 7.8: Potential Applicability of General Data Collection Approaches

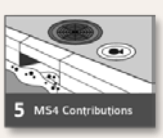
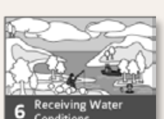
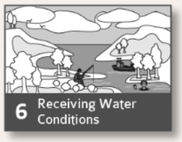
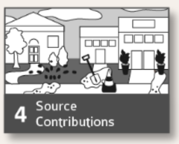
Level	Program Element	Internal Tracking	External Reporting	Site Investigations	Interviews	Surveying & Testing	Monitoring & sampling	Special investigations	External reporting
	Administrative activities	⊙							⊙
	Facilitation activities	⊙							⊙
	Data collection activities	⊙							⊙
	Awareness, knowledge, & attitudes				⊙	⊙		⊙	
	Information seeking	⊙						⊙	⊙
	Pollution reporting	⊙						⊙	⊙
	Participation and involvement	⊙	⊙		⊙	⊙		⊙	⊙
	Administrative and procedural behaviors	⊙	⊙	⊙		⊙		⊙	⊙
	Implementation of control measures	⊙	⊙	⊙		⊙	⊙	⊙	⊙
	Regulatory compliance		⊙	⊙		⊙	⊙	⊙	⊙
	Source pollutant loads			⊙		⊙	⊙	⊙	⊙
	Site / source hydrology			⊙		⊙	⊙	⊙	⊙
	Urban runoff quality			⊙			⊙	⊙	⊙
	Urban runoff hydrology			⊙			⊙	⊙	⊙
	Receiving water quality			⊙			⊙	⊙	⊙
	Hydromodification impacts			⊙			⊙	⊙	
	Beneficial use protection			⊙			⊙	⊙	

Table 7.9: Potential Data and Information Resources[1]

Outcome Level	Examples of Data and Information Resources
 	☑ Receiving water and MS4 monitoring programs ☑ Regulatory agencies and research institutions (SCCWRP, WERF, etc.) ☑ Online repositories, directories, and databases (CERES, SWAMP, etc.) ☑ Published or unpublished research, literature, and technical reports ☑ Special investigations ☑ MS4 maintenance inspections
	☑ Facility or site inspections, monitoring, development plans, etc. ☑ Published research, literature, and technical reports ☑ BMP performance studies ☑ Third party submission of monitoring data ☑ Special studies and investigations ☑ Published or unpublished research, literature, and technical reports
 	☑ Interviews, surveys, tests, and quizzes ☑ Facility or site inspections ☑ Third party submission of compliance data ☑ Special investigations ☑ Published or unpublished research, literature, and technical reports (community-based social marketing studies, etc.)
	☑ Annual compliance reports, source inventories and databases, etc. ☑ Completed effectiveness assessments

[1] This is a general summary for illustration only. See Sections 4.0 through 6.0 for more detailed listings of potential resources applicable to each outcome level.

7.5 Data Analysis

The last consideration for any targeted outcome is how the data that are collected will be evaluated. As noted above, specificity is critical. Managers may often have a better idea of how they will collect data than what they will do with it. Failing to identify specific analytical approaches up front is a common mistake that can severely limit the explanatory value of data. Moreover, the choice of analytical method can dictate what specific metrics should be used, how the data should be collected, and the quality of the result.

Table 7.10 provides examples of Data Analysis Approaches and Methods that can be used as a basis for identifying and developing the data analysis activities for your program. The example data analysis approaches and methods presented in **Table 7.10** can then be applied to the various outcome level results.

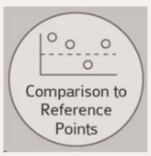
7.6 Relationships between Outcomes

Although this document has focused on individual outcomes, a critical objective is to understand how outcomes are related. Strategic integration of individual outcomes focuses on understanding how the outcomes relate to or influence each other and can be used to address all six Outcome Levels. By evaluating program implementation, target audience, and source impact planning and assessment components, managers can improve the measurability and understanding of outcomes. For example, managers must first understand the relationship of program implementation to changes in awareness or behavior, or of individual behaviors to pollutant load reductions. These program-level results may be used to interpret broader concepts such as changes in runoff quality that result from individual changes in behavior or the cumulative impact of several individuals changing their behavior.

Figure 7.2 presents three objectives that can be used to evaluate the relationships between outcomes.

Objective 1 focuses on how program implementation influences knowledge and awareness and the target audience's actions. The initial goal of any stormwater program is to provide information and to identify approaches to communicating it effectively. Knowledge and awareness regarding stormwater pollution is one bridge to the target audience eliminating PGAs and implementing BMPs. Other external factors will assist in building the bridge to action.

Table 7.10: General Approaches to Data Analysis

	**Qualitative assessment**	**Confirmation** -- e.g., confirmation (Y/N) that a stormwater hotline was operated during the year, or that outreach materials were made available at a building counter. **Completion** -- e.g., confirmation (Y/N) that a specific task was completed. For example, completion of a brochure or updating of a source inventory. **Narrative assessment**
	**Descriptive statistics** (counts [incl. quantification and tabulation], averages, variance, etc.)	*Descriptive statistics* are numbers that are used to summarize and describe data. The word "data" refers to the information that has been collected from an experiment, a survey, an historical record, etc. Any other number we choose to compute also counts as a descriptive statistic for the data from which the statistic is computed. Several descriptive statistics are often used at one time, to give a full picture of the data.
	**Comparison to established reference points**	Comparisons to established reference points include established targets [targeted outcomes, discharge prohibitions, WQS, required activity levels, etc.], or other reference points ["state of the art," other programs, previous results, baseline values, etc.].
	**Temporal change** (Simple change [absolute or %] or statistical trends)	The most general goal of trend analysis is to look at data over time. For example, to discern whether a given indicator such as copper concentrations in a receiving water has increased or decreased over time, and if it has, how quickly or slowly the increase or decrease has occurred.
	**Spatial analysis** (spatial variability, comparisons between watersheds or other geographic areas, etc.)	Spatial analysis allows comparisons between watersheds or other geographic areas. Impacts of runoff and/or control measures can be evaluated based on characteristics of the geographic regions (differences in land use, geology and geomorphology, hydromorphology, etc.). The ability to conduct spatial analysis is generally only limited by the availability of appropriate data for spatial characteristics and project budget.

For example, establishing recycling facilities or curbside pickup or recyclables provides the needed structure to enable the target audience to implement the BMP of properly disposing of reuseable materials. Neighborhood focused programs are also bridges or external factors that can encourage residents to reduce irrigation, use IPM or eliminate car washing in the streets.

Objective 2 looks at how source contributions are related to MS4 and receiving water conditions. As discussed in Section 4.0, the significance of source contributions will depend on many factors including proximity to the MS4 or receiving water, seasonal differences in the probability of pollutants entering waterways, and the ability of the target audience to take actions that will effectively control the source. These are all factors to consider in evaluating the impact of a source on receiving waters and the ability to reduce the impact.

Finally, Objective 3 addresses the relationship between Program Implementation and Receiving Water Conditions. To evaluate such relationships, managers must inevitably consider each of the other specific outcomes established between Levels 1 and 6. Success can ultimately be determined only through a “weight of evidence” that considers all available results. Approaches that seek direct correlations between program implementation and water quality improvement are likely to yield simplistic and unsatisfying results.

Outcome Level 6	Outcome Level 5	Outcome Level 4	Outcome Level 3	Outcome Level 2	Outcome Level 1
Receiving Water Conditions	**MS4 Contributions**	**Source Contributions**	**Target Audience Actions**	**Barriers & Bridges to Action**	**Stormwater Program Activities**
Sources & Impacts			**Target Audiences**		**Implementation**
Objective 1: Relating Program Implementation to Target Audiences and Sources					
				How is Stormwater Program Implementation related to Barriers and Bridges?	
			How are Barriers and Bridges related to Target Audience Actions?		
		How are Target Audience Actions related to Source Contributions?			
Objective 2: Relating Source Contributions to MS4 and Receiving Water Conditions					
	How are Drainage Area and Source Contributions related to MS4 conditions?				
How are MS4 Contributions related to Receiving Water Conditions?					
Objective 3: Relating Program Implementation to Receiving Water Conditions					
How do all of the above elements combine to address the relationship of Stormwater Program Implementation to Receiving Water Conditions?					

Figure 7.2: Questions Guiding the Evaluation of Relationships between Outcomes

This page intentionally left blank

Section 8.0 Interpretation and Use of Results

*This section identifies how the desired analyses that were identified within the **Stormwater Strategic Plan** can be conducted, reported out on, and used to improve the stormwater program. This section also includes examples of various effectiveness assessments that have been conducted by municipal stormwater programs throughout the state. These examples will assist other stormwater program managers in determining what metrics they may want to utilize for their program and/or how they may conduct their analyses and use the results.*

8.1 Background

Once the strategy for the program effectiveness assessment has been developed, the stormwater program manager should identify the data that is necessary to conduct the assessments and ensure that the approach and infrastructure for the data collection is in place. This step is critical in order to be able to conduct the desired analyses and report out on the goals and metrics identified within the assessment strategy.

Actual Outcome - a measured condition or implementation result.

Using the data collected, the stormwater program manager will be able to determine the **Actual Outcome** of the assessment.

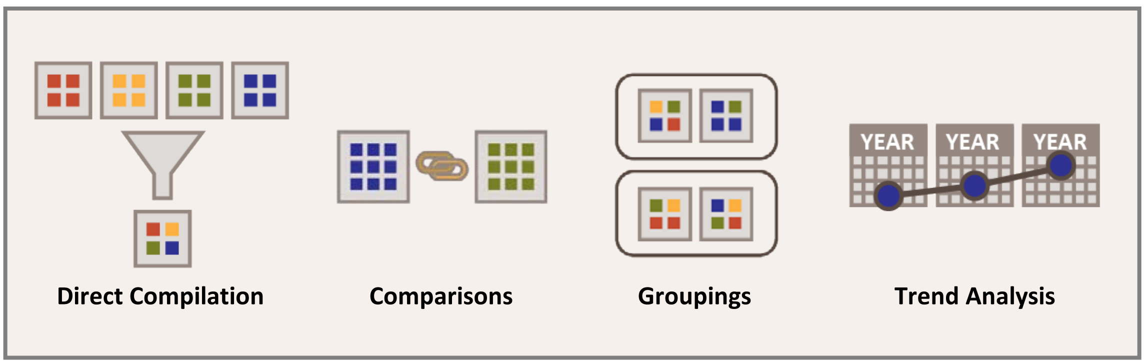
The **Actual Outcome** can then be compared to a **Targeted Outcome** to form the basis of the **Assessment Result**.

The **Assessment Result** describes the relationship of Actual and Targeted Outcomes and, in doing so, ties the planning and assessment processes together.

The analyses can assist stormwater program managers in assessing progress in meeting intermediary goals, long-term goals, and identifying programmatic changes that may be necessary in order to obtain a stormwater program goal.

In addition, the results may be presented to interested parties including regulators, the general public, and/or public officials so that they may understand the benefits of the stormwater program. Graphic presentations of the results should be developed and included in annual reports, ROWDs, and/or press releases or other types of communications to the public to identify how the stormwater program has been effective.

The analyses may assist the stormwater program manager in documenting permit compliance, determining trends, and/or estimating pollutant load reductions. The most common types of analyses utilized as a part of a PEA including the following:



8.2 Program Modifications

Once an effectiveness assessment has been conducted, stormwater program activities should be modified, as needed, based on the results of the assessment. Modifications may include:

- Improving upon areas that did not accomplish goals;
- Expanding upon efforts that proved to be effective;
- Discontinuing efforts that may no longer be productive; or
- Shifting priorities to make more effective use of resources.

Once effective strategies are fully implemented, fewer resources may be needed to continue the effective activities, which will allow resources to be shifted to address new issues. In addition, since new pollutant issues may arise that require attention, shifting priorities may result in a need to shift resources.

Since the development and implementation of a stormwater program is often a phased effort and higher Outcome Levels often require relatively large amounts of data over a period of years, many programs will initially assess the effectiveness of the lower Outcome Levels. However, assessments should be conducted at the highest Outcome Level supported by the data, and program managers should strive to address the higher Outcome Levels as soon and as often as possible.

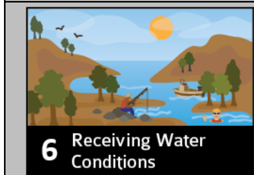
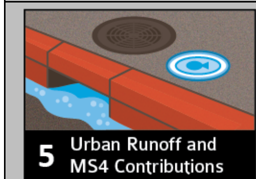
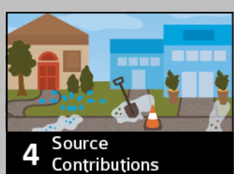
8.3 Example Program Effectiveness Assessment Analyses

This section includes examples of effectiveness assessments that have been conducted by municipal stormwater programs throughout the state. They are organized first by Outcome Level and then by Program Element and summarized in **Table 8.1**. Each example includes the source of the information in case additional information is desired.

For each example, the following is provided:

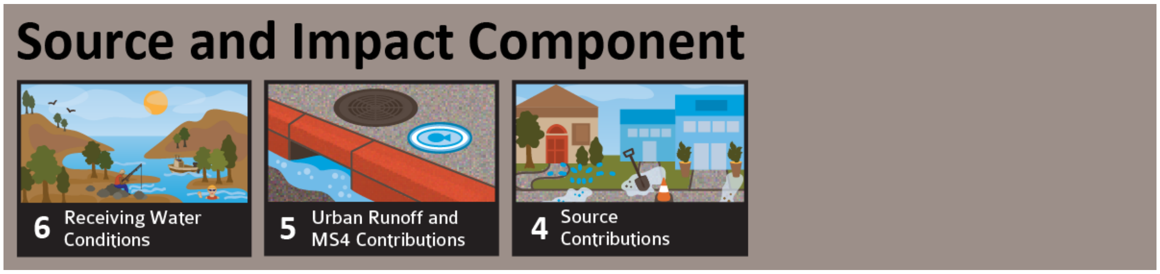
- A description of the program activity;
- A description of the effectiveness assessment method utilized. The methods are categorized as direct compilation, comparisons, groupings and/or trend analysis;
- The **Actual Outcomes** of the assessment are described in each example and, if available, compared to Targeted Outcomes;
- An Assessment Result is provided either by comparing it to the **Targeted Outcome** or by presenting conclusions that may be drawn from an analysis of the results; and
- Finally, how a program manager could use the information.

Table 8.1 Effectiveness Assessment Examples

	Program Element					
Outcome Level	**Construction**	**New Development / Redevelopment**	**Residential**	**Industrial/ Commercial**	**Municipal**	**Overall Program**
Source and Impact Component						
					- SCVURPP: Trash Removal/ Reduction	- Orange County Stormwater Program: Nutrient Load Reduction
					- City of Stockton: SSO Response and Reduction	
	- County of San Diego: BMP Implementation	- City of Sacramento: Stormwater Quality Improvement Program	- Orange County Stormwater Program: HHW Program - City of Stockton: HHW Program - City of Stockton and County of San Joaquin: Stream Clean Up Events	- City of San Diego: Restaurant BMPs	- Caltrans: Traction Sand & Deicing Salt - San Joaquin County: Landscape and Pest Management	
Target Audience Component						

	Program Element					
Outcome Level	**Construction**	**New Development / Redevelopment**	**Residential**	**Industrial/ Commercial**	**Municipal**	**Overall Program**
			- Orange County Stormwater Program: Public Awareness Survey - Palo Alto Regional Water Quality Control Plant: Car Wash Coupons - San Francisco Water Pollution Prevention Program: Thermometer Exchange - City of Fresno: Used Oil Collection	- Palo Alto Regional Water Quality Control Plant: Vehicle Service Facilities	- Orange County Stormwater Programs: Municipal Facility Inspections - City of Stockton: Field Crew Inspections	
			- Orange County Stormwater Program: Public Awareness Survey - Orange County Stormwater Program: Incident Reporting		- County of San Joaquin: Capital Improvement Projects - Orange County Stormwater Program: Inspector Training	
Stormwater Management Program Component						
	- Fresno-Clovis SWQMP: Inspection Tracking		- Orange County Stormwater Program: Impression Tracking	- County of Sacramento: Inspection Tracking	- Caltrans: Training Program - Caltrans: Vegetated Slope Inspections	

8.4 Source and Impact Component



6 Receiving Water Conditions

Level 6 assessments can be used to draw conclusions about overall program effectiveness, but results usually require extended periods of monitoring and analysis. Moreover, it's important to keep in mind that receiving water conditions usually reflect more than stormwater discharges. Other influences that can have a significant impact include sanitary sewer overflows, rising groundwater, agricultural, and other non-point discharges such as aerial deposition.

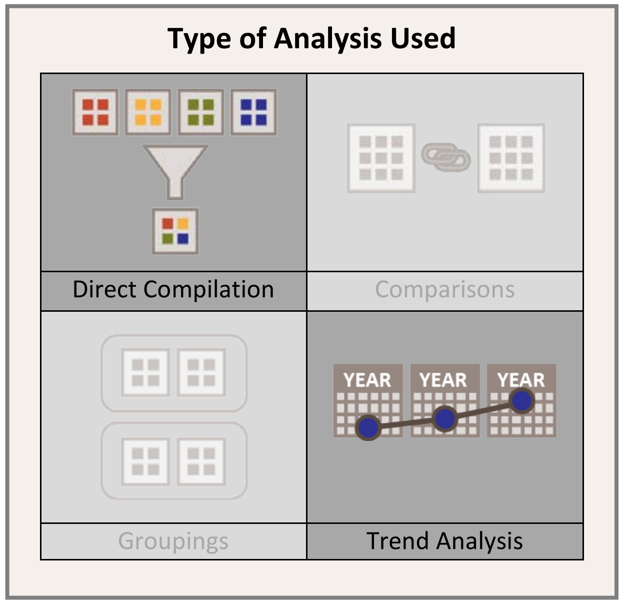
Level 6 Outcomes can provide managers with the data and information necessary to determine the overall success of their programs, or to better direct them to the most important constituents and sources. Receiving water conditions can be evaluated in a variety of ways, including comparison of monitoring results to benchmarks, compliance with water-quality standards, protection of biological integrity, and beneficial use attainment. Each of these approaches presents its own issues and challenges for monitoring design, representative data collection, and interpretation of results.

OP Overall Program

Ultimately stormwater program managers may need to assess the effectiveness of the overall stormwater program in order to determine if there has been a measurable change in receiving water quality or other environmental conditions. Such assessments can be difficult and expensive therefore, it is critical that stormwater managers understand the purpose of the assessment, the type of data needed to support the assessment, and the appropriate assessment methods.

Project

Orange County Stormwater Program: Nutrient Load Reduction



Over the years, high nutrient loads from the Newport Bay watershed have resulted in excessive algal growth in the Bay. In fact, large macroalgal blooms were seen from the 1980's through the middle 1990s. The blooms can adversely impact the beneficial uses by depressing oxygen levels, and fouling beaches, swimming and boating areas. Based on the concerns related to the nutrient loads, several actions occurred simultaneously in the watershed that directly addressed the nutrient loadings.

First, in 1996 the State of California placed Newport Bay and the San Diego Creek watershed on the Clean Water Act Section 303(d) list of water quality limited segments and listed them as a high priority for nutrient Total Maximum Daily Load (TMDL) development. This listing was in response to qualitative and quantitative measurements indicating exceedances of the nutrient-related Water Quality Objectives (WQOs) for Newport Bay. A nutrient TMDL was adopted in 1998. As a part of the TMDL implementation plan, the County of Orange initiated a Regional Monitoring Plan (RMP). Each year (now quarterly) a report is submitted on behalf of the watershed Permittees. The RMP quantifies the endpoints of the TMDL including the seasonal nutrient loadings from the watershed, the nutrient concentrations in San Diego Creek, and the extent, magnitude and duration of algal blooms in Newport Bay.

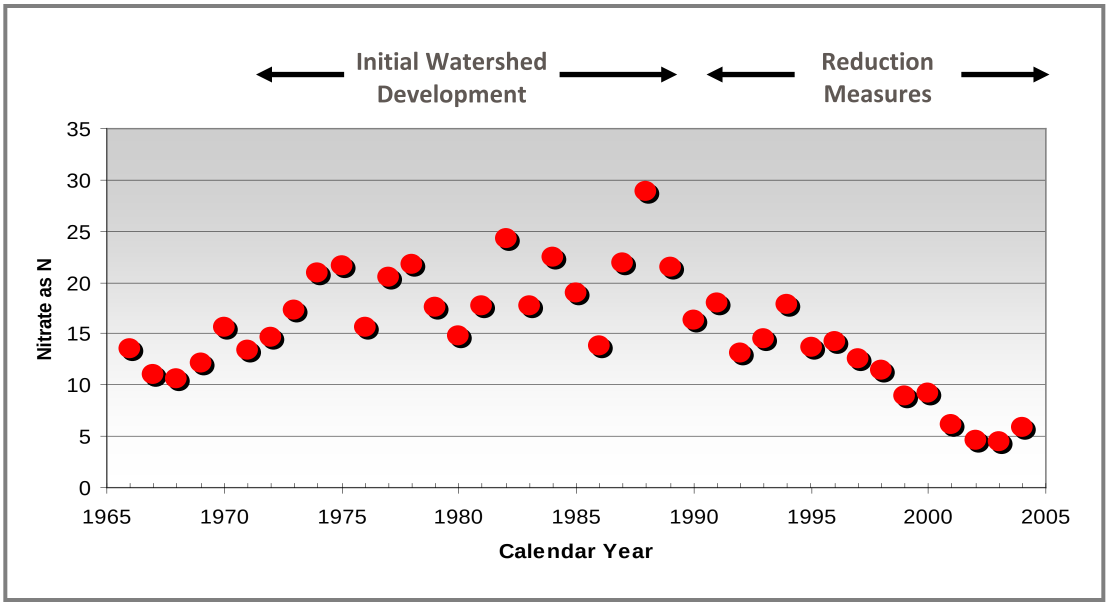
Second, in July 1990 the Santa Ana Regional Water Quality Control Board (RWQCB) issued Waste Discharge Requirements to three nurseries requiring substantial reductions in nutrient loads. In response, the nurseries implemented BMPs to reduce runoff such as drip irrigation systems and recycling systems which have substantially reduced the nitrogen loads.

Third, the Irvine Ranch Water District (IRWD) began diverting water from San Diego Creek into the San Joaquin Marsh. The San Joaquin Marsh project was completed by IRWD to restore and enhance the water quality cleansing of the marsh. Water is diverted from San Diego Creek during dry weather, routed through the marsh, and then returned to the Creek. Water quality monitoring has demonstrated that the Marsh has significantly reduced the nitrogen levels and sediment content of the water that is discharged to San Diego Creek.

Fourth, based on the known elevated concentrations of nitrogen in the groundwater and concerns regarding the discharge of groundwater within the watershed, the RWQCB adopted Order No.R8-2004-0021. As a result of this permit, a Nitrogen and Selenium Management Program (NSMP) and Working Group of stakeholders was established to address these concerns through a five-year work effort. The NSMP work plan includes monitoring, the development of a conceptual model, identification of sources and loads and data gaps, testing of treatment controls, evaluation/development of a trading/offset program, and an evaluation of the nutrient TMDL targets and allocations.

Fifth, the Transportation Corridor Agencies (TCA) constructed the Eastern Transportation Corridor in the Peters Canyon Channel watershed (a tributary of San Diego Creek and upper Newport Bay). The Corridor is depressed below grade in the vicinity of Interstate 5 and Jamboree Road. An extensive subdrain system was constructed to lower the groundwater table below the roadway surface. Groundwater in this area is high in nitrates, and historically the aquifer free surface has been above the flow line of Peters Canyon Channel, resulting in groundwater discharge to the Channel and upper Newport Bay. The Toll Road subdrain system currently discharges to the sanitary sewer, reducing the load of nitrogen from groundwater that would otherwise discharge through Peters Canyon Channel.

As a result of these diverse and multi-faceted efforts within the watershed to address the nitrogen loads, water quality has improved within Newport Bay and the watershed over the past 30 years as evidenced by the long-term nitrate concentrations, the total nitrogen loads from San Diego Creek and the reduction in algal biomass within Newport Bay.



Historical Nitrate Concentrations in San Diego Creek (1965-2005)

Algal Biomass July 1996

Algal Biomass July 2005

Assessment Result

✓ **Actual Outcome**: Average Summertime Total Nitrogen Load reduced from ~4000 lb/day in 1985 to 1100 lb/day in 1995 to 400 lb/day in 2000.

Targeted Outcome: 1100 lb/day by December 31, 2002 and 900 lb/day by December 31, 2007

Assessment Result: Targeted outcome achieved approximately 7 years early.

Next Steps

In addition to using this information to demonstrate compliance with regulatory requirements, this information can be used to plan approaches to achieving similar results for other constituents or for nutrients in other locations. It can also be used to plan direction and focus of future program efforts (level of effort needed to maintain TN levels, resources that can be directed to other issues).

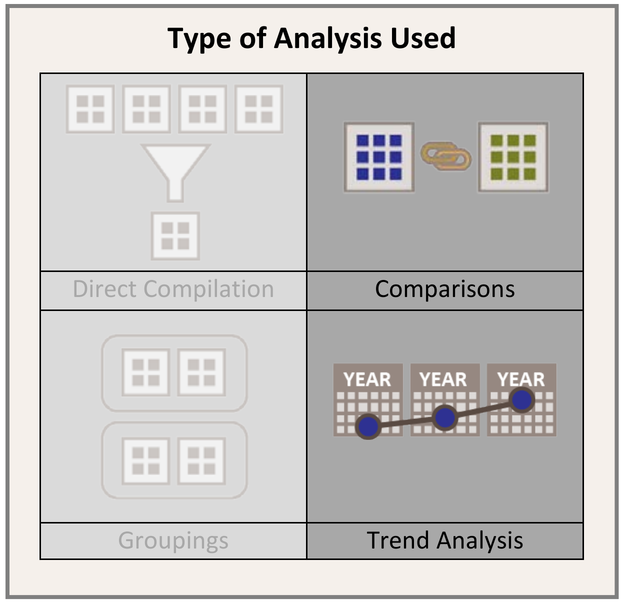
Source: *Newport Bay Watershed Action Plan, August 2006 and the Regional Monitoring Program Report for the Newport Bay/San Diego Creek Watershed Nutrient TMDL November 2005. For more information visit the Orange County website www.ocwatersheds.com and go to "Stormwater Program"*

M Municipal Program Element

Improvements in the environment may be observable and directly attributed to a program's control measures. One example is in the case of trash/ debris removal.

Project

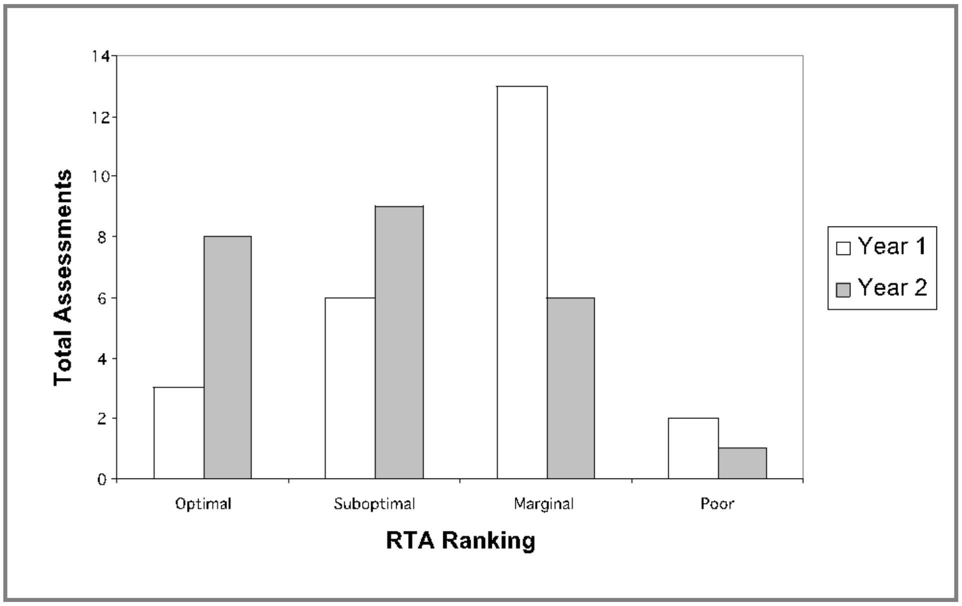
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP): Trash Removal/Reduction



In 2004, the SCVURPPP co-permittees documented the location of 64 potential trash problem areas located in creeks or in close proximity to a creek (i.e., banks). The co-permittees then conducted trash evaluations from 2004 to 2006 at potential trash problem areas using rapid creek trash assessments[1]. The goals of the assessments were to establish baseline conditions with regard to trash accumulation and types, and track changes overtime. This type of assessment can also provide information on sources of trash found in creeks that can guide future implementation of control measures.

As a preliminary step to assessing changes in receiving water quality, trash assessment scores at 24 creek sites assessed during multiple years were evaluated. Assessment scores indicated improvement in 67% (i.e., 16 of 24) of sites assessed. Trash removal during assessments conducted in Year 1 and management actions put into place between assessments may have resulted in the improved conditions during Year 2. It is difficult to evaluate trends in site condition however, without more data since seasonal and inter-annual variability of trash levels for these sites is unknown.

[1] Rapid Trash Assessment (RTA) Protocol developed by the San Francisco Bay Regional Water Quality Control Board (Water Board) was used in FY 2004-05 to qualitatively assess trash conditions in wadeable creeks. In FY 2005-06, the RTA was refined to better evaluate conditions of trash-impacted sites in urban creeks, as opposed to the Water Board's RTA which addressed both rural and urban creeks. The refined protocol is named the "Urban RTA".



Comparison of Trash Assessment Scores Conducted by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) at 24 Sites in Two Consecutive Years.

Assessment Result

Actual Outcome: Condition of 67% of sites identified as trash problem areas improved with respect to trash accumulation in one year moving from marginal to suboptimal or optimal.

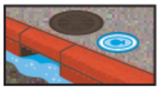
Targeted Outcome: no information

Assessment Result: Results demonstrated that measurable change/improvements can occur in one year.

Next Steps

If information is available regarding strategies and BMPs employed at each site, then this information can be used to identify successful approaches by comparing BMPs/strategies to results. This information can then be used to focus future efforts on implementing the more successful strategies/BMPs.

Source: *For more information go to http://www.scvurppp-w2k.com/pdfs/0506/Trash_memo_AR_FY0506.pdf*



5 Urban Runoff & MS4 Contributions

Level 5 Outcomes can be an important expression of successful program implementation because they provide a direct linkage between the sources regulated by Stormwater Management Programs and the receiving waters they're intended to protect. In addition, they apply exclusively to MS4s. By providing a direct linkage between sources and receiving waters, Level 5 Outcomes allow managers to determine how well their programs may be functioning. Measurement of Level 5 outcomes is fairly straightforward, but their analysis is complicated by a variety of factors such as the comingling of discharges, and the characteristics and timing of storm events.

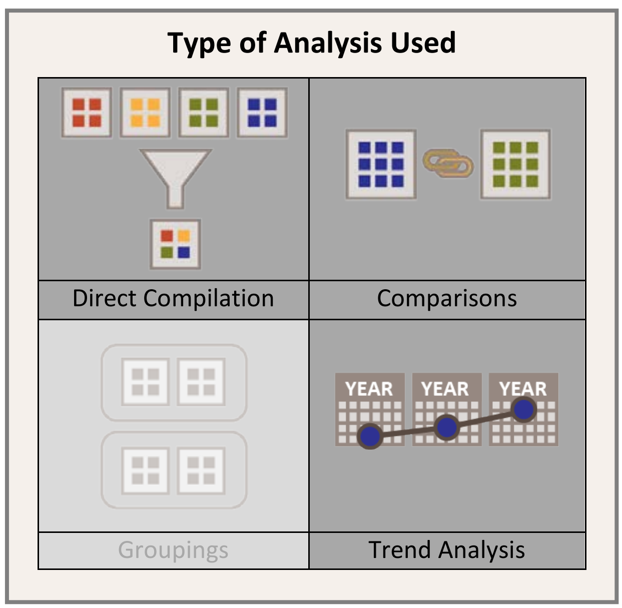
M Municipal Program Element

Indicators of effectiveness for municipal operations would include confirmation that guidance has been developed, numbers and types of BMPs that are being implemented, and/or training sessions that have been conducted.

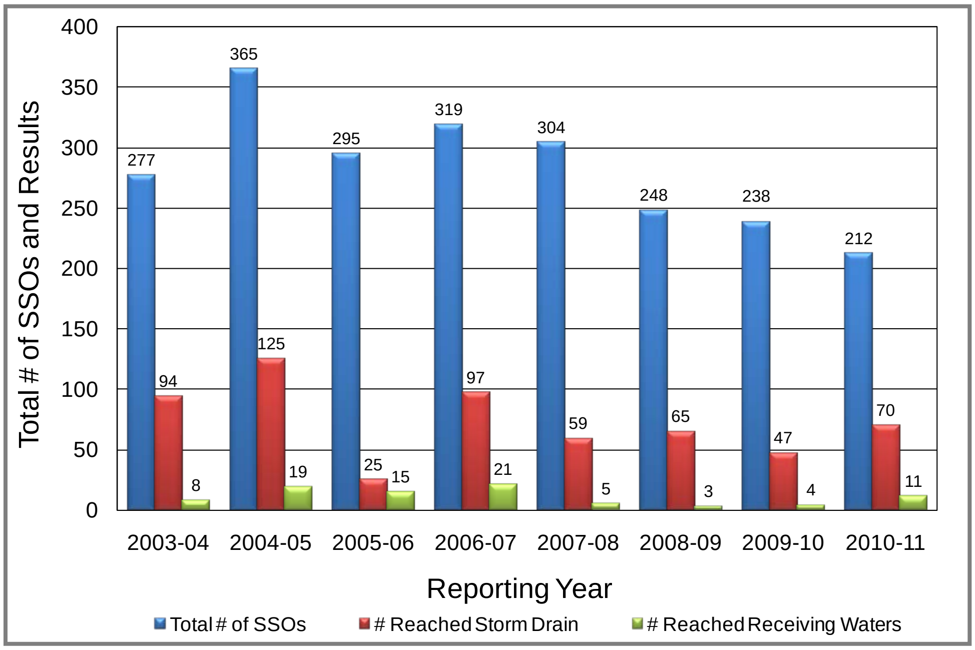
Project

City of Stockton: SSO Response and Reduction

The City developed and implements a Sanitary Sewer Overflow Emergency Response Program (SSOERP). When possible, the City prevents the SSOs from entering the storm drain system or receiving waters. The City also reviews and revises the SSOERP as needed.



- Since 2003, 2,258 SSOs have occurred and were responded to by the City.
- Of the 2,258 spills, 582 reached the storm drain system and 86 of them reached a receiving water.
- In general, a downward trend has been observed in the total annual number of SSOs.



Total Number of Sanitary Sewer Overflows and the Results

Assessment Result

Actual Outcome: The number of SSOs has decreased from 365 in 2004-05 to 212 in 2010-11. In addition, the number reaching the storm drain has decreased from 125 in 2004-05 to 70 in 2010-11.

Targeted Outcome: no information

Assessment Result: The program has been effective in reducing the total number of SSOs and the number reaching the storm drain. This in turn should result in reduced levels of pollutants in the MS4.

Next Steps

To further evaluate improvements in discharge quality, measurement of pollutants including BOD, TSS and nitrogen compounds could be measured in the storm drain system during wet weather in locations where SSOs have occurred.

Source: *June 2012 City of Stockton and County of San Joaquin NPDES Municipal Stormwater Program Report of Waste Discharge and Proposed Stormwater Management Plan. Section 5 Municipal Operations. For more information visit the City of Stockton website* *http://www.stocktongov.com/government/departments/municipalUtilities/utilStorm.html*

4 Source Contributions

Source reductions are changes in the amounts of pollutants or reductions in flow associated with specific sources before and after BMPs are employed. Because source loadings determine the characteristics of the runoff discharged through MS4s, managers stand to benefit from a better understanding of how they can be reduced. Level 4 Outcomes provide program managers with feedback regarding reductions in the amounts of pollutants associated with specific sources before and after a BMP is employed.

Stormwater pollutant load reductions from proper disposal of materials can be estimated by the amount of materials collected. This includes:

- The amount of household hazardous waste turned in at collection centers or the amount of used motor oil turned in at collection facilities, (this data is collected by the California Integrated Waste Management Board);
- The volume of trash collected in public accessible trash receptacles or during coastal or stream clean up; or
- The amount of spilled material cleaned up after accidents, separate sewer overflows, or the termination of an illicit connection or non-stormwater discharge.

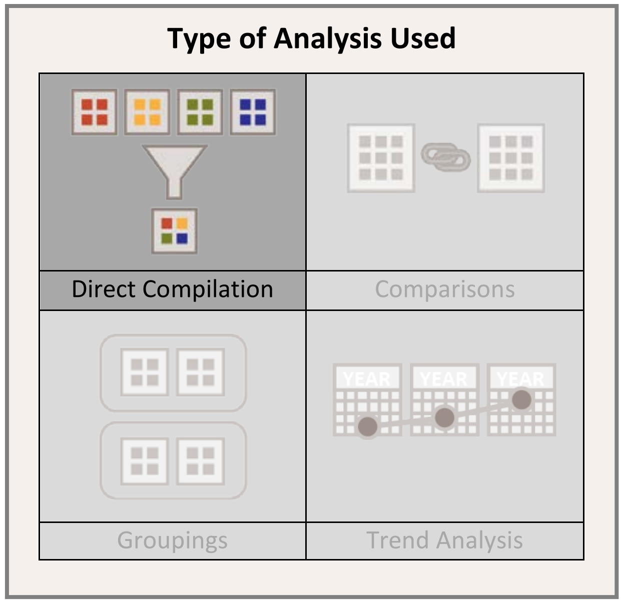
These quantities can be estimated and reported as stormwater pollutant loads avoided.

ND/R New Development/Redevelopment Program Element

Assessment at this Level for the New Development/Redevelopment program will include comparisons between project runoff volumes or pollutant loads avoided through site level BMP implementation. More comprehensive BMP installations (at a subwatershed or watershed level) can be documented at higher Outcome Levels.

Project

City of Sacramento: Stormwater Quality Improvement Program



Directly measuring the reduction of loads due to stormwater treatment requires a significant level of effort and resources due to the extensive inflow and effluent characterization required. In Sacramento's North Natomas Development, all urban runoff is treated by wet extended detention basins. Specific studies are underway to determine the effectiveness of the basins. In the meantime, load reductions were estimated by ascertaining average pollutant reduction percentages for similar type basins from the WERF/ASCE International Stormwater Best Management Practices (BMP) Database and applying that to the North Natomas urban discharge. Using the example of dissolved lead, the stormwater program estimated load reduction as follows:

Ave. dissolved lead reduction % for 3 similar basins from the database	60%
Sacramento area urban discharge dissolved lead annual loading (from Sacramento Urban Discharge Characterization 2005)	0.0004kg/ac
Natomas watershed area	6100 ac
Total estimated dissolved lead annual load reduction	.0004 x 6100 x .6 = **1.46 kg**

Assessment Result

Actual Outcome: For this basin, a load reduction for lead is estimated to be 1.46 kg/year.

Targeted Outcome: no information

Assessment Result: This BMP is projected to be effective in reducing lead loadings.

Next Steps

This estimated load can be used as a baseline or reference point that can be compared to actual load reductions when that information is available. Additionally, the estimated load reduction could be compared to estimated load reductions for other BMPs to help identify the most effective BMP for this basin or similarly situated basins.

Source: *For more information go to www.sacstormwater.org*

C Construction Program Element

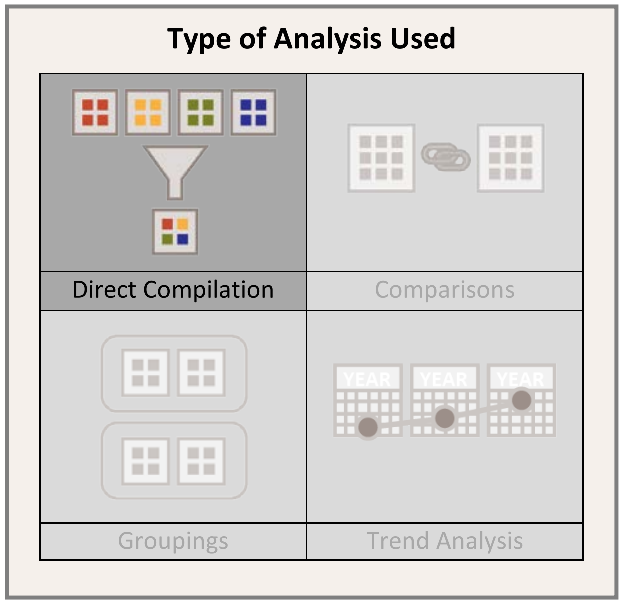
Assessment at this Level for the Construction program will include comparisons between project runoff volumes or pollutant loads avoided through site level BMP implementation. More comprehensive BMP installations (at a subwatershed or watershed level) can be documented at higher Outcome Levels.

Project

County of San Diego: BMP Implementation

In FY 2002-03 and 2003-04, the County of San Diego estimated potential load reductions resulting from BMP implementation at permitted construction sites using an indirect method that incorporates assumptions regarding the relative amounts of sediment likely to be discharged from unprotected versus protected sites. Because of the extremely large number of permitted sites open throughout the year (more than 8,000 in a typical year), the County determined that collecting detailed site-specific data would not be feasible.

Instead, staff employed a less direct approach of projecting potential reductions from estimated levels of site protection. This analysis relied heavily on the use of literature values and based on some broad assumptions about site conditions. Using GIS, each site's total acreage was estimated by matching Assessor's Parcel Numbers to parcel maps.



- The acreage of each parcel with an active building permit was multiplied by the estimated percentage of disturbed acreage and multiplied by the fraction of the year that the project was active.
- To derive the loading estimation, this total was multiplied by 8.3 tons per acre per year. This loading factor is a regionally-adjusted literature value that estimates how much sediment would be discharged annually from a one-acre unprotected site. Since 100% protection was assumed after BMP protection, the difference was calculated using the entire 8.3 tons.
- Using this equation, the total potential reduction in sediment loading as a result of BMP implementation was estimated at 3,409 tons in FY 2002-03 and 12,642 tons in FY 2003-04.

Assessment Result

Actual Outcome: For this basin, a load reduction for sediment was estimated to be 3,400 tons/year for 2002-03 and 12,600 for tons/year for 2003-04.

Targeted Outcome: no information

Assessment Result: Increased use of BMPs is projected to result in greater reduction of sediment loadings.

Next Steps

The parameter that was actually measured in this example is the rate of BMP implementation in the service area. Looking at this by itself would provide an assessment result at Outcome Level 3. By converting this to projected sediment reduction, it provides information on whether implementation of BMPs can be expected to result in measurable reductions of sediment loadings. Whether or not measurable reductions are projected would inform decisions as to whether it is worthwhile to implement these BMPs or focus reduction efforts elsewhere. Or these estimated projections can be used as a baseline against which to compare actual measured reductions.

Source: *County of San Diego. Jurisdictional Urban Runoff Management Plan (JURMP) Fiscal Year 2002-03 Annual Report and Fiscal Year 2003-04 Annual Report; Fifield, Jerald S. Designing for Effective Sediment and Erosion Control on Construction Sites. ForresterPress: Santa Barbara, California. 2001. For more information contact Watersheds@sdcounty.ca.gov.*

PE Public Education Program Element

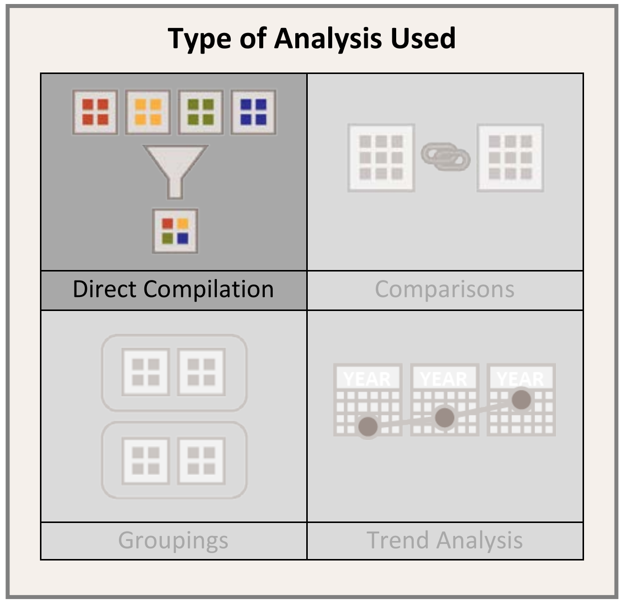
Indicators of Level 4 Outcomes in the residential program may include the amount of material that is diverted to a household hazardous waste (HHW) center and materials removed in creek cleanups (although this material has already left the source it is good to track how much material is removed from the waterways).

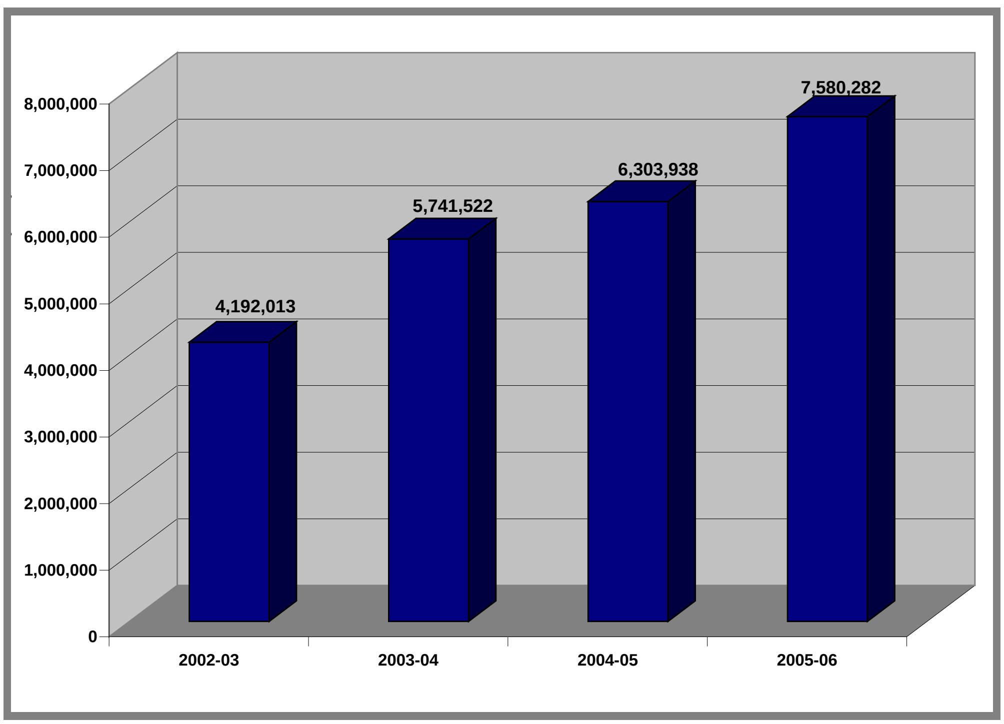
Project

Orange County Stormwater Program: Household Hazardous Waste Program

As a part of the stormwater program the County of Orange has a household hazardous waste collection program that is administered by the Integrated Waste Management Department (IWMD). The program includes four sites which are located in the cities of Anaheim, Huntington Beach, San Juan Capistrano, and Irvine.

In 2005-2006 over 7,580,000 pounds of household hazardous waste was collected. This represents a 20% increase from 2004-2005 in which over 6,300,000 pounds were collected and an 80% increase from 2002-2003 in which 4,200,000 pounds were collected.





Household Hazardous Waste Collected in Pounds

Assessment Result

Actual Outcome: The quantity of household hazardous waste collected increase by 80% between 2002 and 2006.

Targeted Outcome: no information

Assessment Result: This could be an indicator that more people are properly disposing of hazardous materials or it could be an indicator that people are using larger quantities of hazardous materials.

Next Steps

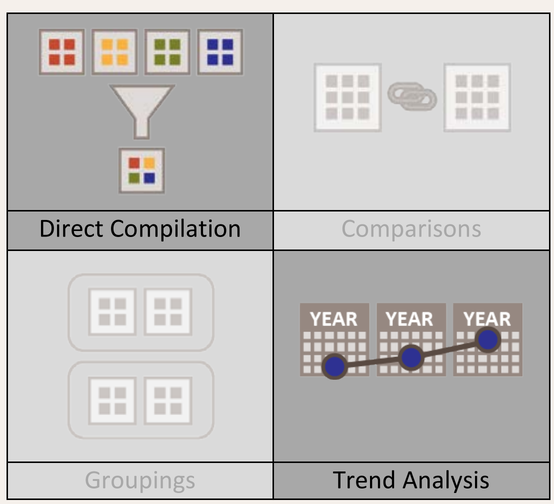
If the quantity collected is coupled with the population served by each location, per capita comparisons could be made to see if there is any difference in amount collected at each of the 4 sites. Evaluation of publicity, ease of access to the facility or other factors could be compared to quantities collected to determine future approaches to implementing the HHW program to optimize collection. One or two questions regarding how residents heard about the program or what types of wastes they are bringing could also provide additional information on the effectiveness of the program with respect to communication with the target audience and effectiveness of the program with respect to diverting pollutants from waterways.

Source: *2005-2006 Unified Annual Report, Section 5 Municipal Activities. For more information visit the Orange County website www.ocwatersheds.com and go to "Stormwater Program"*

Project

City of Stockton: Household Hazardous Waste Program

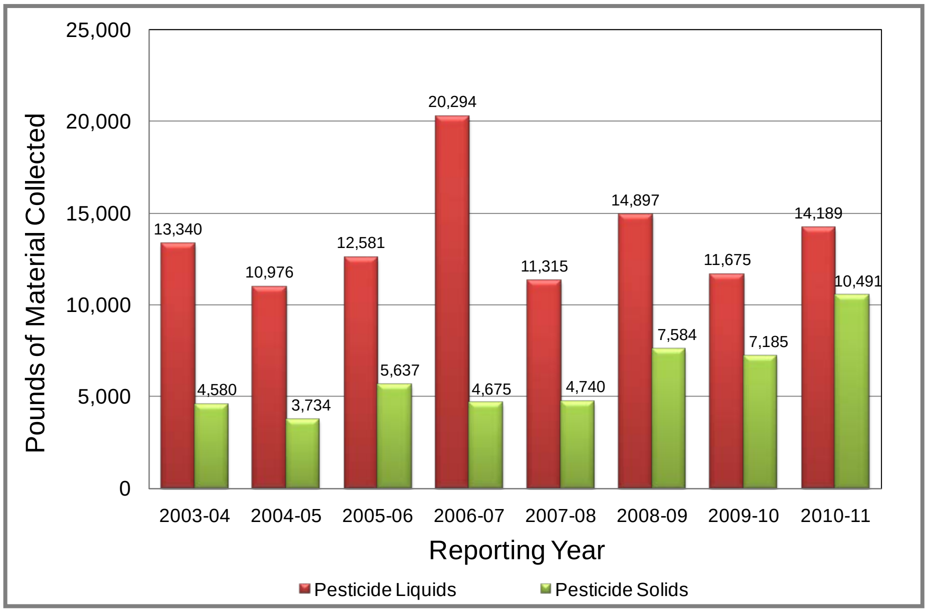
Type of Analysis Used



The Permittees raised awareness about HHW collection services and are increased the amount of HHW that is being disposed of properly, thus reducing the potential load of pollutants that could enter the storm drain system. The Permittees are also coordinating the HHW program with their Pesticide Water Quality Based

Plan to ensure that these materials are safely and properly disposed of. The key messages are provided through printed materials as well as the website.

- Since 2003, almost 110,000 pounds of pesticide liquids and over 48,000 pounds of pesticide solids have been collected at the HHW centers.
- Since 2003, there has been a general increase in the amount of pesticide solids collected at the HHW, while the amount of pesticide liquids has been more variable.



Pesticide-Related Waste Collected in Pounds

Assessment Result

Actual Outcome: Quantity of pesticides collected annually has generally increased from ~17,920 pounds in 2003-2004 to ~24,680 pounds in 2010-2011, an increase of 38%.

Targeted Outcome: no information

Assessment Result: The quantity of pesticides turned in by residents has been generally increasing, which may be due to a number of factors.

Next Steps

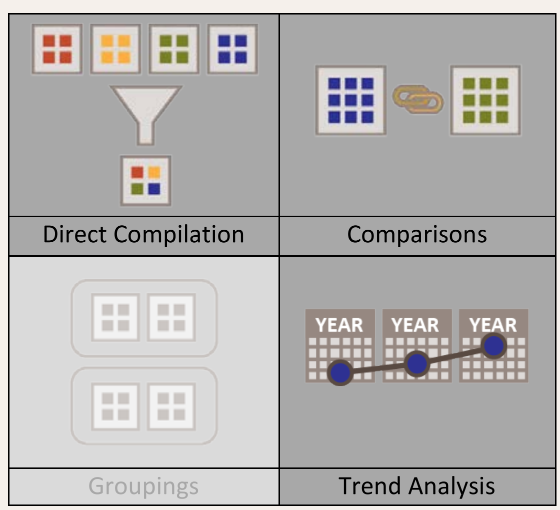
Which outreach strategies have been most effective could be explored by evaluating what new materials or strategies have been employed since 2003. In particular, the quantity of liquid pesticides collected in 2006-2007 was substantially higher than any other year. Determining if a different strategy was used that year or if there were external factors (e.g., amount of pesticides sold) that may have contributed to this result could be very informative. In addition, there was a significant increase in the quantity of solid pesticide collected in 2008-2009 and 2010-2011, compared to previous years. Programmatic changes or external factors that contributed to these increases could also be used to guide future outreach efforts.

Source: *June 2012 City of Stockton and County of San Joaquin NPDES Municipal Stormwater Program Report of Waste Discharge and Proposed Stormwater Management Plan. Section 4 Public Education and Outreach. For more information visit the County of San Joaquin website http://www.sjcleanwater.org/ or the City of Stockton website http://www.stocktongov.com/government/departments/municipalUtilities/utilStorm.html*

Project

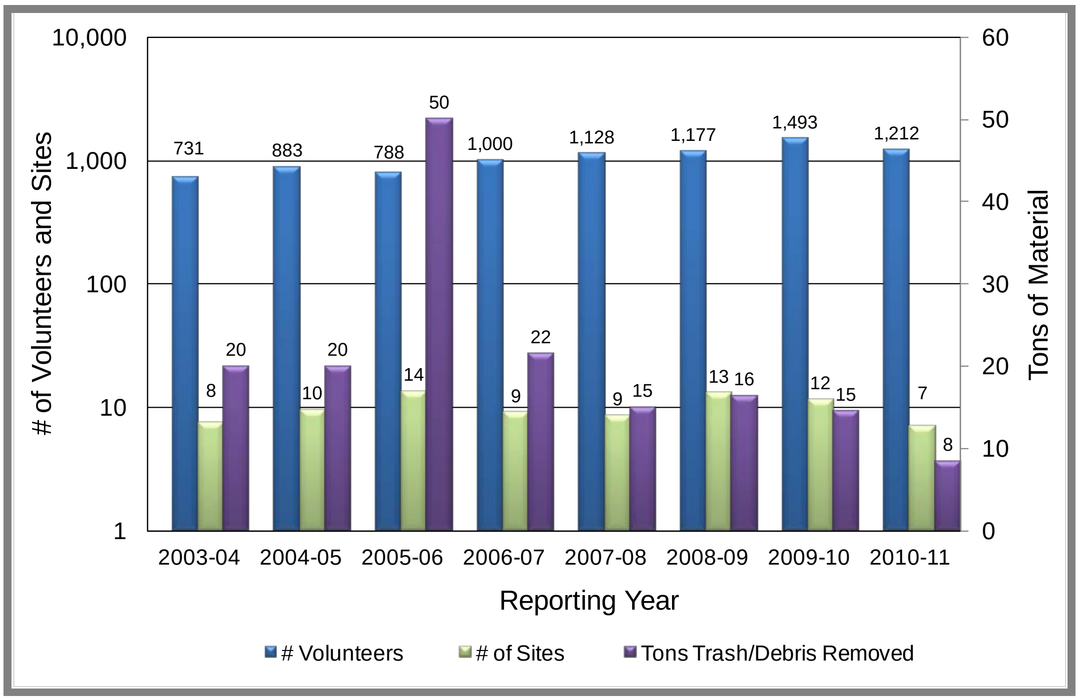
City of Stockton and County of San Joaquin: Stream Clean Up Events

Type of Analysis Used



Participation rates and quantities of trash collected indicate that the public is aware of the education campaign and community events sponsored by the Stormwater program. Measurable quanitities of materials have been removed from the local creeks and streams, thus reducing the amount of materials that may adversely impact the local waterways.

- Since 2003, approximately 8,400 volunteers have participated in local stream clean up events.
- As a result, approximately 166 tons of trash and debris have been removed.
- Since 2003-2004, an overall increasing trend in the number of volunteers has been apparent.
- The number of volunteers has been consistently high since 2006-2007.
- As a result of each cleanup event, a consistent amount of trash and debris has been removed annually from local streams and tributaries.
- Note: there may be a reporting anomaly with the data for 2005-2006.



Results of the Community Stream Cleanup Events

Assessment Result

Actual Outcome: The program has observed a steady to increasing participation rate by volunteers and a steady quantity of trash and debris removed.

Targeted Outcome: no information

Assessment Result: The Stormwater Program has been able to maintain a good level of trash and debris removal using volunteers over a 7-year period indicating an effective outreach effort over a sustained period.

Next Steps

Reviewing the outreach strategies used for this program could help identify effective approaches that could be used for other aspects of the Stormwater Program that also rely on outreach and education. It appears that the amount of trash and debris removed in recent years may have decreased slightly. It would be worthwhile to determine if this is because sites are starting out cleaner than in previous years which would speak to the overall effectiveness of this program or if external factors have contributed to this decrease (weather for example). It would be worthwhile to determine the reason for the huge spike in trash and debris removed in 2005-06 (more than twice as much removed than in any other year) and if it is related to a specific effort by the Stormwater Program.

Source: *June 2012 City of Stockton and County of San Joaquin NPDES Municipal Stormwater Program Report of Waste Discharge and Proposed Stormwater Management Plan. Section 4 Public Education and Outreach. For more information visit the County of San Joaquin website http://www.sjcleanwater.org/ or the City of Stockton website http://www.stocktongov.com/government/departments/municipalUtilities/utilStorm.html*

I/C **Industrial/Commercial Program Element**

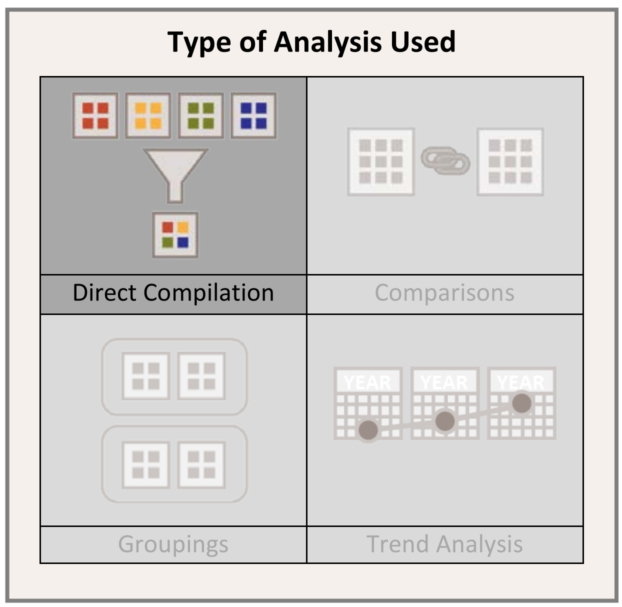
Project

City of San Diego: Restaurant BMPs

San Diego estimated the potential loadings generated from washing floor mats by making the following assumptions:

# of mats per restaurant	2
Square footage of mat surface	4 sq. ft.
Average thickness of grease on mats	0.02 inch
Volume of grease on mats.	0.0067 cu. Ft
Density of grease.	57 lbs/cu. Ft
Grease washed from two mats daily	0.76 lbs
Assume washing 365 days/year	277 lbs/year

By calculating the number of sources (10,342 in area) multiplied by the effectiveness of the BMP (indoor washing assumed to be 100% effective) and estimating the rate of implementation achievable (estimated at 30-50%), they determined that the potential load reduction by implementing BMPs at restaurants could achieve a reduction of 860,000 to 1,430,000 lbs grease annually.



Assessment Result

Actual Outcome: Implementation of BMPs at restaurants could achieve a reduction of 860,000 to 1,430,000 lbs grease annually.

Targeted Outcome: no information

Assessment Result: This indicates that there is value in pursuing BMP implementation because of the significant potential load reduction that could result.

Next Steps

The potential reduction determined in this example could be used as a Targeted Outcome against which to measure actual results and BMP implementation rates. Alternatively, if a target load reduction for grease were established in another way, comparison of the potential load reduction to the target load reduction would confirm whether this is a worthwhile strategy to pursue.

Source: *Weston Solutions, LWA, and Mikhail Ogawa Baseline Long Term Effectiveness Assessment, August 2005. For more information got to www.projectcleanwater.org/html/wq_assessment.html*

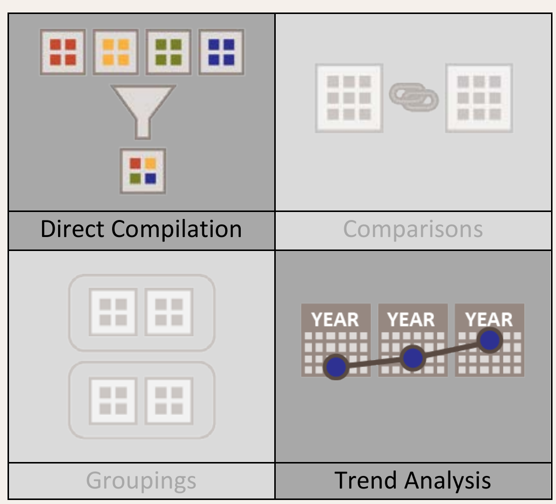
M **Municipal Program Element**

Project

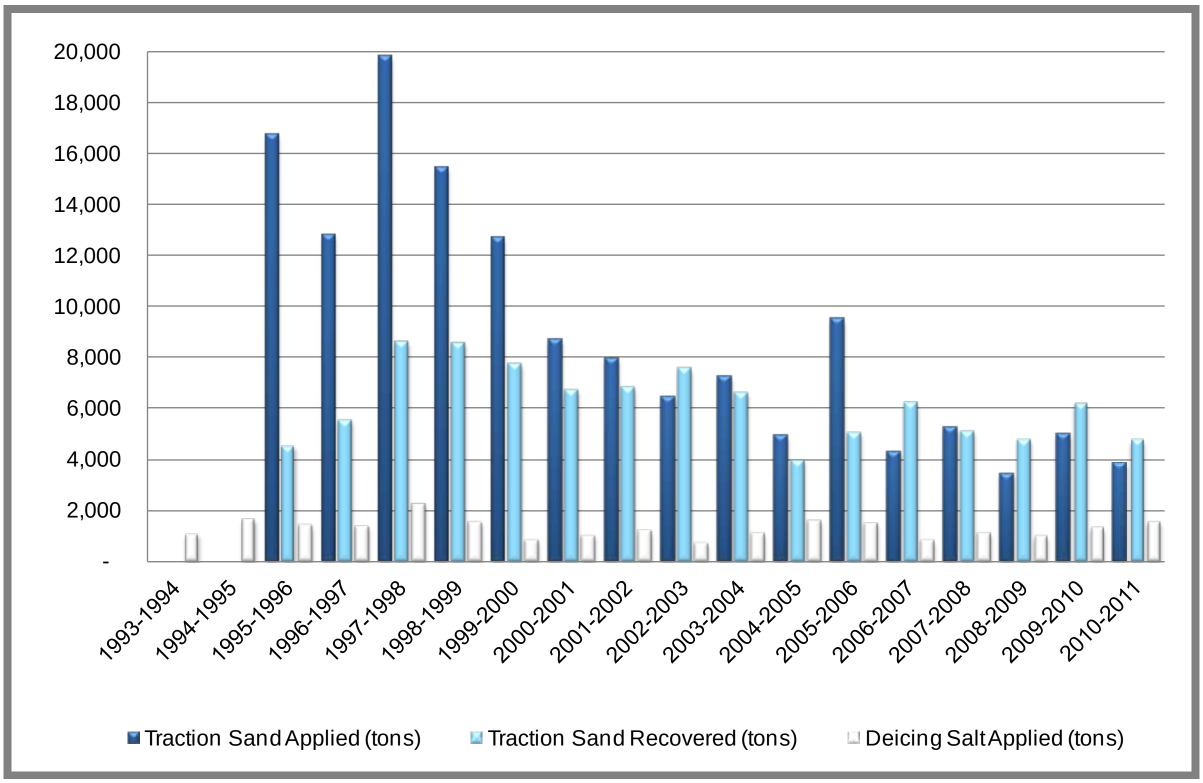
California Department of Transportation (Caltrans): Traction Sand and Deicing Salt

Caltrans has established BMPs for the application of traction sand and deicing salt. The use of these BMPs has resulted in a decrease in the amount of traction sand and deicing salt applied and reduced the amount of material that could potentially end up in the storm drain inlets and/or local waterways.

Type of Analysis Used



- In the Lake Tahoe hydrologic unit, 3,865 tons of traction sand was applied during the 2010-2011 snow season. However, 4,761 tons of traction sand was recovered. This represents a recapture rate of 123%. Several reasons noted within the Deicer Report explain the high recovery rate.
- Since 1995-1996, Caltrans has had an average traction sand recovery rate of 83%, with the recovery efficiency exhibiting an overall increasing trend due to improved BMPs.
- During the 2010-2011 snow season, 1,555 granular tons of salts were used. Since 1993-1994, the amount of granular salt applied has generally been exhibited on a downward trend.



Traction Sand Application and Removal and Deicing Salt Application in the Lake Tahoe Hydrologic Unit (District 3), by Fiscal Year

Assessment Result

Actual Outcome: In 2011, the traction sand recovery rate was 123%. Since 1995, there has been a decrease in traction sand applied and an increase in the recovery rate.

Targeted Outcome: no information

Assessment Result: Since 1995-1996, Caltrans has had an average traction sand recovery rate of 83%, with the recovery efficiency exhibiting an overall increasing trend due to improved BMPs.

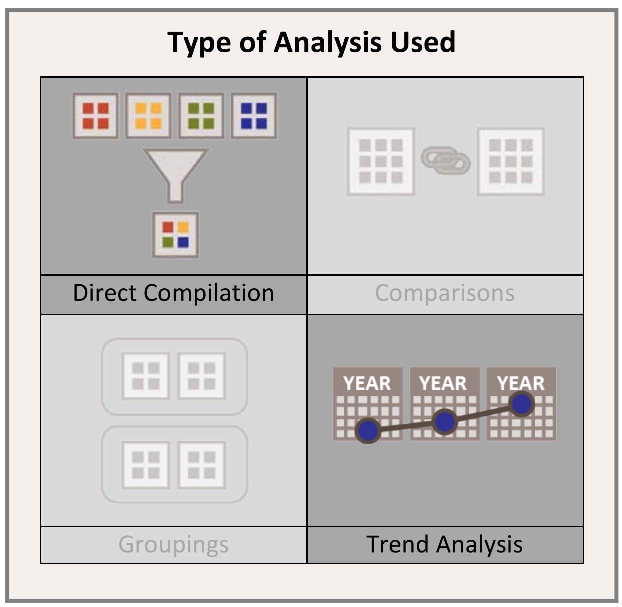
Next Steps

A reasonable targeted outcome for this example would be to achieve a 100% recovery rate. This appears to have been consistently achieved since the 2006-2007 snow season. This information can be used to identify effective BMP strategies. In addition, the effort needed to maintain this recovery rate could be determined and resources could possibly be shifted to activities where reductions are still needed.

Source: *April 2013 California Department of Transportation Statewide Stormwater Management Program Annual Report Fiscal Year 2011-2012. Chapter G Program Effectiveness Assessment. For more information visit the Caltrans website* *http://www.dot.ca.gov/hq/env/stormwater/annual_report/curent_ar.pdf*

Project

San Joaquin County: Landscape and Pest Management



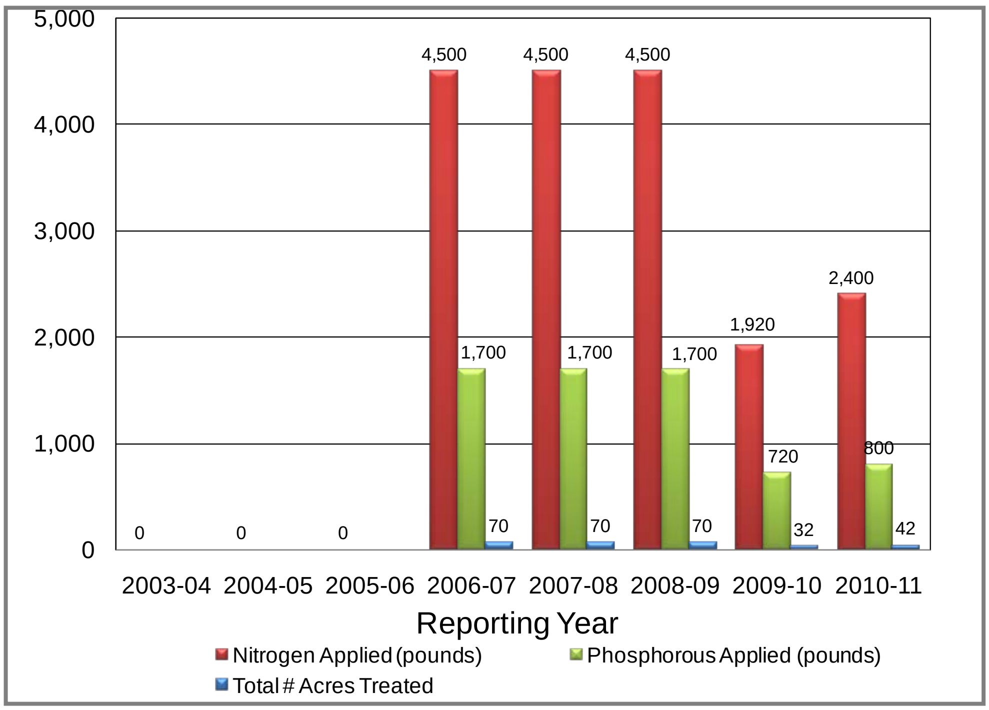
The San Joaquin County municipal stormwater program implements a comprehensive municipal operations program to ensure that the operations and maintenance activities are performed in a way that minimizes the pollutants generated. As a part of the program they track a number of parameters to assist them in identifying if the program is being implemented in accordance with the

SWMP and related performance standards. One set of parameters that they track include the following:

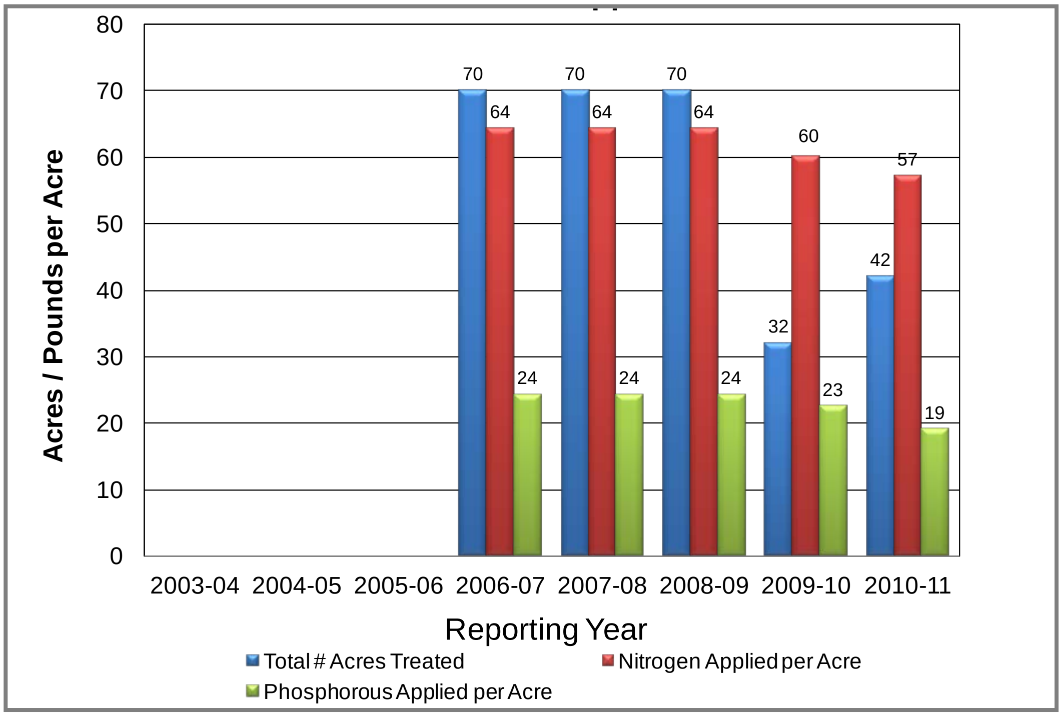
Landscape and Pest Management

- Total number of acres treated with fertilizers;
    - Total pounds of nitrogen applied;
    - Total pounds of phosphorous applied;

The County's Parks and Recreation Department has been generally reducing the amount of fertilizers used within its jurisdiction. The County has reduced the total amount of nitrogen and phosphorous applied per acre by approximately 11% and 21%, respectively.



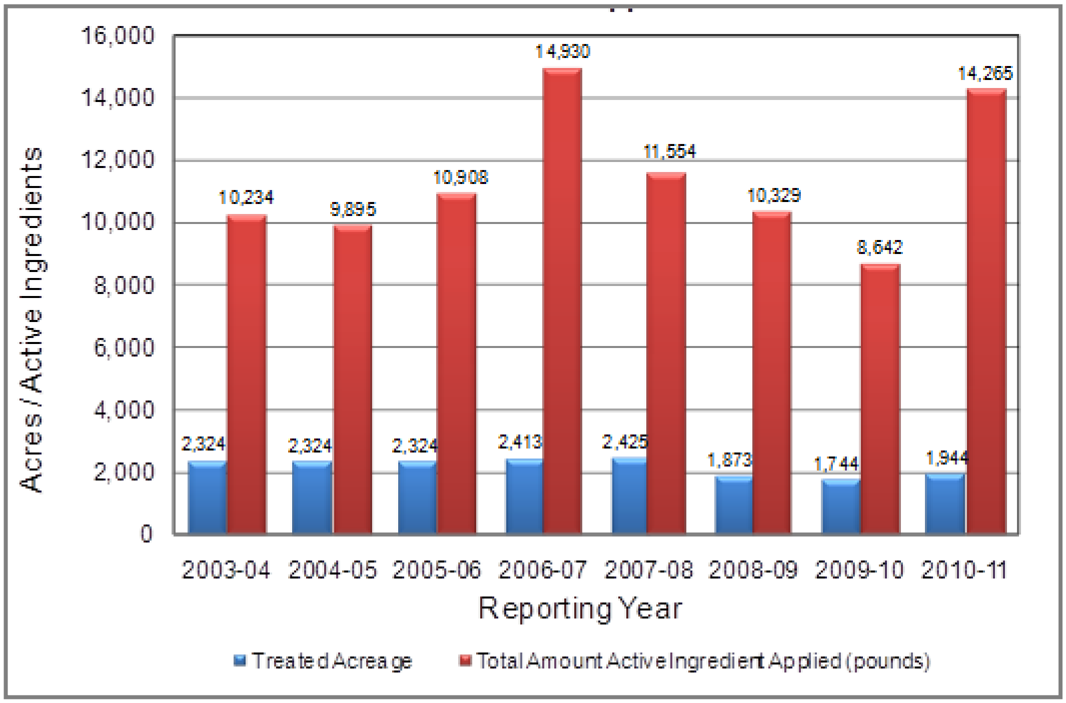
Fertilizer Application: Total Amount of Nitrogen and Phosphorus Applied



Fertilizer Application: Pounds Applied per Acre

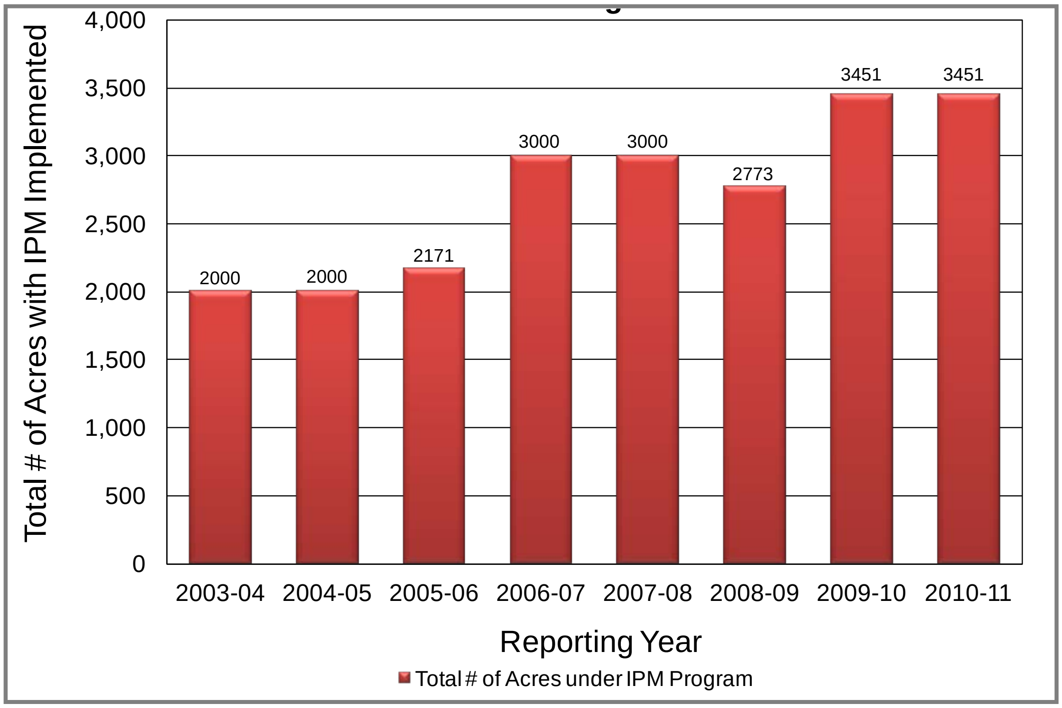
- Total number of acres treated with pesticides; and
  - Types of products used
  - Name of active ingredient and pounds of active ingredient applied
- Total number of acres under the IPM practices and types of practices used.

To better account for the volume and type of pesticide used, County staff maintains an internal inventory on pesticide use and tracked Department of Parks and Recreation reported pesticide use. After the 2006-2007 fiscal year, the County began to significantly reduce its application of pesticides, with the exception of 2010-2011. In 2010-2011, there was an increase in pesticide use due to one-time levee maintenance activities that required immediate attention to correct findings by state and federal levee inspectors. The County has reduced its pesticide use by 42%, from a high of 14,930 pounds in 2006-2007 to a low of 8,642 pounds in 2009-2010.



Pesticide Application

The County implements an IPM program that requires the use of less toxic or non-toxic approaches to pest management. Some of the IPM alternatives that are being employed include hand weeding, mulching, pruning, plant selection, and landscape design. Since 2003, there has been a 72.5% increase in the acreage covered by the IPM program.



IPM Program Application

Assessment Result

Actual Outcome: The County has reduced the total amount of nitrogen and phosphorous applied per acre by approximately 11% and 21%, respectively. In addition, since 2003, there has been a 72.5% increase in the acreage covered by the IPM program. Overall, the County has reduced its pesticide use by 42%, from a high of 14,930 pounds in 2006-2007 to a low of 8,642 pounds in 2009-2010.

Targeted Outcome: no information

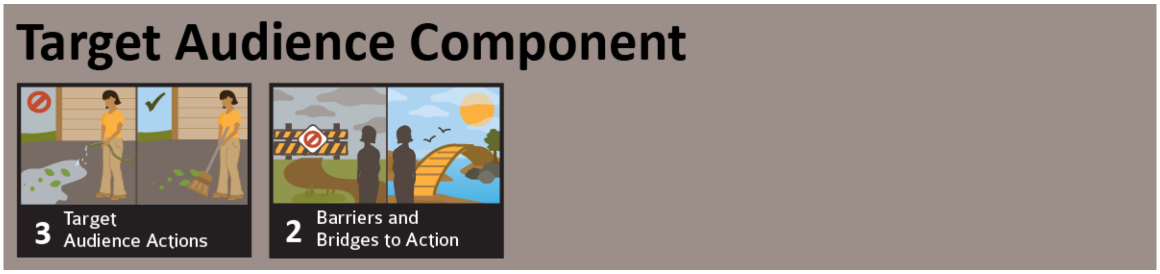
Assessment Result: The County has implemented its program to meet the goal of the SWMP to reduce pesticide usage and to increase the use of IPM.

Next Steps

In addition to demonstrating effective implementation of it pesticide reduction program, this information can be used to evaluate effectiveness at Outcome Level 4, Load Avoidance.

***Source:** June 2012 City of Stockton and County of San Joaquin NPDES Municipal Stormwater Program Report of Waste Discharge and Proposed Stormwater Management Plan. Section 5 Municipal Operations. For more information visit the County of San Joaquin website http://www.sjcleanwater.org/*

8.5 Target Audience Component



3 Target Audience Actions

One of the primary purposes of a Stormwater Management Program is to change behaviors in target audiences so that the activities that they are engaged in are protective of water quality. Level 3 Outcomes build on knowledge and awareness (Level 2) by providing program managers with feedback on what types of behaviors are occurring in Target Audiences, and whether their programs are actually inducing changes in them.

Level 3 Outcomes provide program managers with feedback on how effective the program has been in motivating target audiences to change their behavior and implement appropriate BMPs.

PE Public Education Program Element

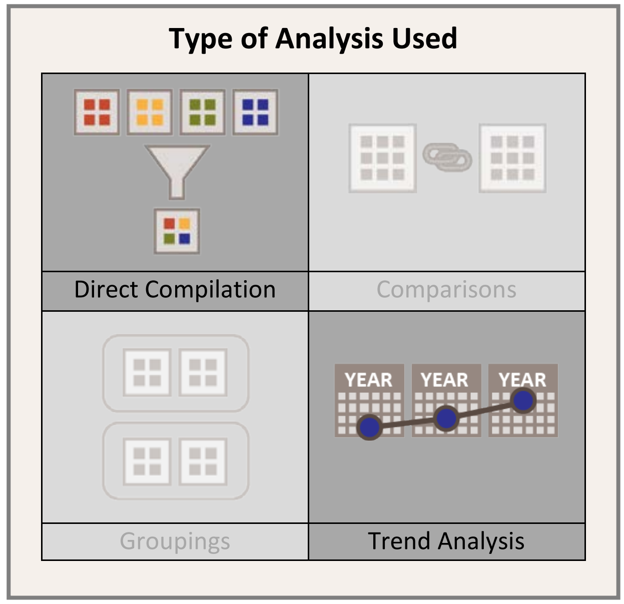
Indicators of effectiveness with respect to target audience actions include reported changes such as picking up after pets, disposing of household hazardous wastes correctly, and using a broom instead of a hose to clean up an area. Although these changes are reported, and thus, they are qualitative, they are still a good indicator of the willingness to change.

Project

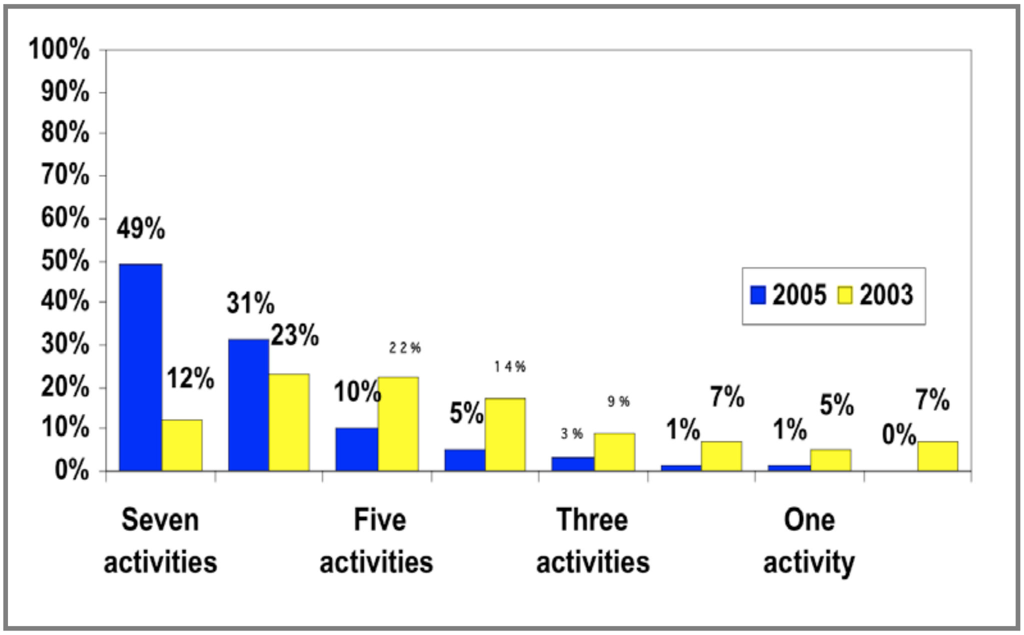
Orange County Stormwater Program: Public Awareness Survey

The Santa Ana Region municipal stormwater permit requires the Permittees to measurably change the behavior of target communities and thereby reduce pollutant releases to the municipal storm drain system and the environment. On behalf of the 34 co-permittees, the Principal Permittee (County of Orange) developed an approach for the program's public awareness surveys to ensure that the program is effective and able to measure changes in knowledge and behavior.

In May 2003 a public awareness survey was conducted with 1,500 respondents and repeated in November 2005. The purpose of the second survey was to assess the extent to which public awareness had changed and if the residents made any behavior changes as a result of the campaign. A couple of the key findings indicating that the residents were changing their behaviors include the following:



- Roughly two thirds of the respondents indicated that they would change their personal behaviors to make a difference in cleaning up pollution (65%). This represented a 2% increase from the 2003 survey.
- When comparing the 2003 and 2005 surveys, roughly half of the residents reported taking part in the seven activities identified as behaviors that are protective of water quality (activities such as disposing of chemicals correctly, picking up after a pet, etc) in the 2005 survey. This represents a 37% increase from the 2003 survey. This is attributable to the materials that were developed since the materials addressed all seven activities in the survey.



Survey Results: Reported Activity Participation

Assessment Result

Actual Outcome: In 2005, approximately half of the survey participants reported taking part in all seven activities included in the survey. Approximately 80% of respondents reported taking part in at least six of the identified activities.

Targeted Outcome: no information

Assessment Result: Respondents reporting taking part in six or more of the identified activities increased by 45%.

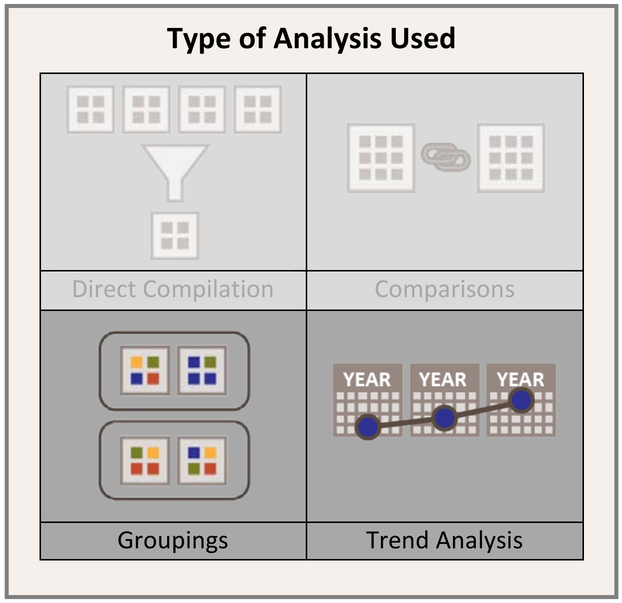
Next Steps

This result was attributed to outreach materials that included specific information about activities that would reduce pollutant releases to the municipal storm drain system. This can be used to identify effective strategies for communicating information to residential audiences. In addition, with this large of a change in reported behavior, the Stormwater Program could explore ways to measure results at higher outcome levels (i.e., changes in water quality or measurable load reductions).

Source: *2005-2006 Unified Annual Report, Section 6 Public Education. For more information visit the Orange County website www.ocwatersheds.com and go to "Stormwater Program"*

Project

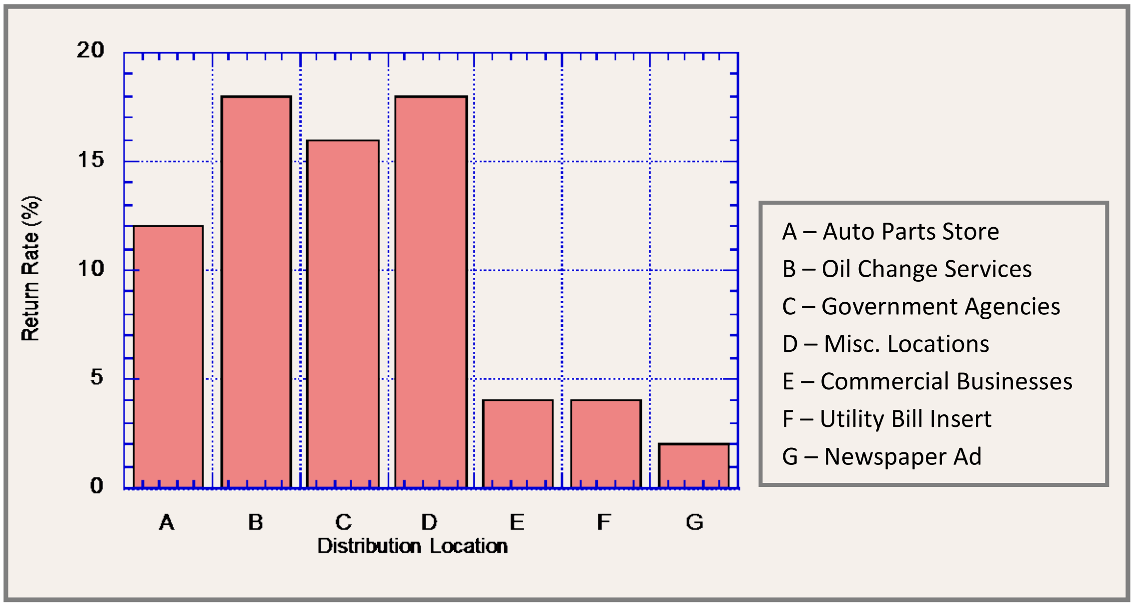
Palo Alto Regional Water Quality Control Plan: Car Wash Coupons



One element of the PARWQCP pollution prevention program is the Clean Bay Business Program targeting vehicle service facilities. One of the ways that the RWQCP publicizes the Clean Bay Business Program is to offer discount coupons to be redeemed at carwashes that qualify as Clean Bay Businesses. The effectiveness of the car wash coupons is evaluated with respect to the percentage of coupons returned and which method of distribution resulted in the most coupons being returned. This was done by using different colored coupons for different methods of distribution, keeping track of how many coupons were distributed using each method and how many coupons of each color are returned.

Between 1994 and 1998, the distribution locations that achieved the highest return rate were oil change services, auto parts stores, and government employee paychecks. Other distribution methods that were used include utility bill inserts; counters at community centers, libraries, and city hall; and local corporation employee paychecks. Even though these methods do not have the highest return rates, they were still employed because they reach residents and help increase their awareness of storm water pollution. Distribution methods such as placing coupons at cars parked at shopping malls and hand delivery to residential homes were tried in previous years but were discontinued because they were very labor intensive and did not generate high coupon return rates. The figure below illustrates the return rates from the various distribution locations in 1998.

The PARWQCP also tracked the rate of coupons redeemed over time. Between 1994 and 1998, the percentage of coupons returned increased from 4% to 13%.



Car Wash Coupon Return Rates

Assessment Result

Actual Outcome: In 1998, carwash coupon return rates ranged from 12-18% for coupons distributed at auto parts stores, oil change services and government agencies. Return rates were less than 5% for coupons distributed at other commercial businesses, in utility bills and in the newspaper.

Targeted Outcome: no information

Assessment Result: Auto parts stores, oil change services and government agencies are better locations than other businesses, utility bills and newspaper ads for distributing information on actions that can reduce water pollution (at least with respect to cars).

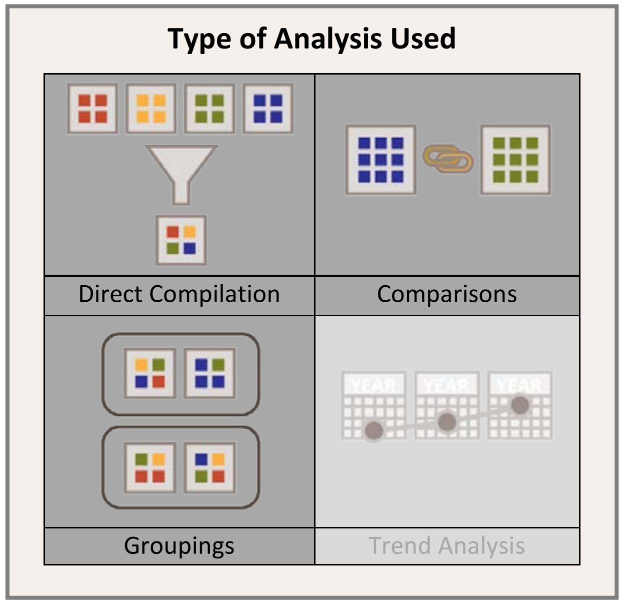
Next Steps

Coupon return rates are a direct measure of a Target Audience Action as opposed to reported behavior from surveys. In addition to measuring behavior change as a result of public outreach, this information can also be used to optimize resources by helping program managers focus on the most effective locations for public outreach.

Source: *Water Environment Research Foundation, 2000. Tools to Measure Source Control Program Effectiveness. WERF Project 98-WSM-2. For more information go to www.werf.org or www.cityofpaloalto.org/public-works/cb-auto.html*

Project

San Francisco Water Pollution Prevention Program: Thermometer Exchange



In partnership with the Solid Waste Management Program, the Department of the Environment and the San Francisco Fire Department, the SFWPPP initiated an extensive public education and outreach campaign designed to encourage residents to turn in mercury thermometers for recycling and thereby keep mercury out of the Bay and Ocean. Every Saturday in May 2000, anyone who turned in a mercury thermometer at one of nine fire stations in San Francisco received a new digital thermometer. The SFWPPP measured the effectiveness of its Mercury Thermometer Education effort based on participation and thermometers collected. During the one-month campaign, 3300 people turned in 4700 thermometers. Almost 40% of the thermometers were collected at one station located in Chinatown.

In addition to tracking participation and thermometers collected, a short intercept survey was conducted at the collection sites. Participants were asked for their zip code and where they had heard about the turn-in events:

- 42% of those surveyed had heard about the program through the newspaper;
- 26% heard about it on the radio;
- 18% heard about it through word of mouth;
- 5% heard about it through television advertisements;
- 3% heard about it through utility bill inserts; and
- 2% heard about it via street posters, fire stations, and Val Packs.

There were some differences geographically with respect to how people had heard about the program:

- A higher than average percentage of respondents at the Chinatown station had heard about the program on the radio (42%).
- In the Marina District, the vast majority had heard about the program in the newspaper (74%) with far less than average mentioning word of mouth (4%) or radio (10%).

When reviewing the responses by week, some changes were seen over time with respect to where people had heard about the program:

- In the first two weeks of the campaign, 64% and 54% respectively reported hearing about the program in the newspaper.
- In the last two weeks of the campaign, this dropped to 24% and 29% respectively.
- Those who said they heard about the campaign on the radio comprised 6% of the responses in the first week. This increased to 25%, 40% and 30% in the second, third, and fourth weeks.
- Word of mouth responses accounted for 14% and 9% of the responses in the first two weeks but increased to 27% and24% of the responses in the last two weeks.

This assessment method was a simple add-on to an existing element of the outreach campaign. It was able to provide the SFWPPP with information on effective outreach methods (i.e., newspaper articles, radio) and provide some insight into what type of approaches work best in different San Francisco neighborhoods.

Assessment Result

Actual Outcome: During the one-month campaign, 3300 people turned in 4700 thermometers. Almost 40% of the thermometers were collected at one station located in Chinatown. Intercept surveys collected information on where participants had heard about the event.

Targeted Outcome: no information

Assessment Result: Two-thirds of participants had heard about the event in the newspaper or the radio. There was a relationship between geographic locations and the most effective form of outreach.

Next Steps

This assessment provided the SFWPPP with information on effective outreach methods (i.e., newspaper articles, radio) and provide some insight into what type of approaches work best in different San Francisco neighborhoods.

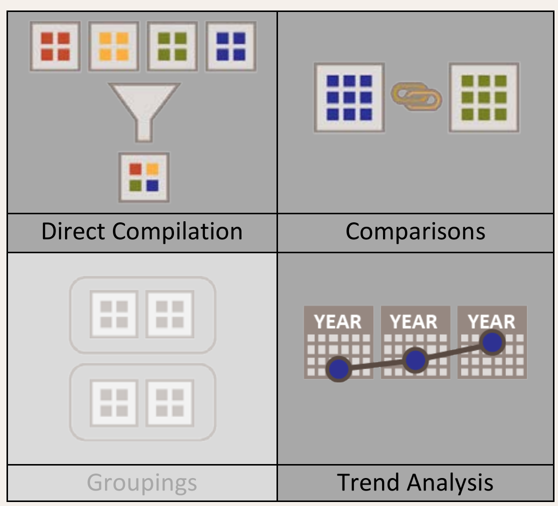
Source: *Water Environment Research Foundation, 2001. Controlling Pollution at Its Source: Wastewater and Stormwater Demonstration Projects. WERF Project 98-WSM-2. For more information go to www.werf.org and click on Publications.*

Project

City of Fresno: Used Oil Collection

One of the significant sources of stormwater pollution is automotive fluids, which is also the largest category of illicit discharge complaints investigated by the Fresno Metropolitan Flood Control District (FMFCD) and its Co-Permittees. By working with CalRecycle, and the Cities of Fresno and Clovis, FMFCD evaluated four years' worth of used motor oil collection data from the two Cities and compared the collection data to illicit discharge response data.

Type of Analysis Used



As shown in Figure 1, used oil collected in the City of Fresno increased 19% from Fiscal Year 2009-2010 to Fiscal Year 2012-2013.

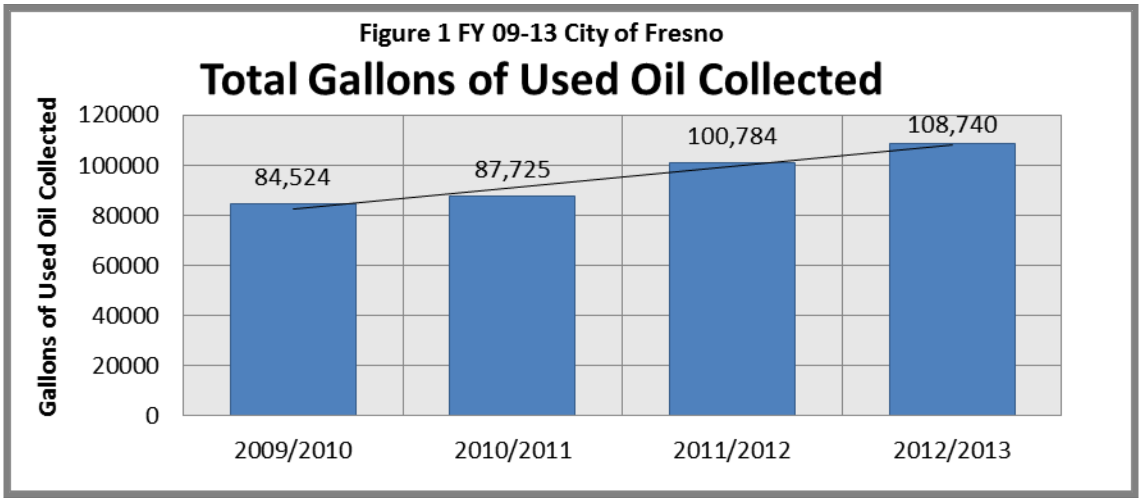
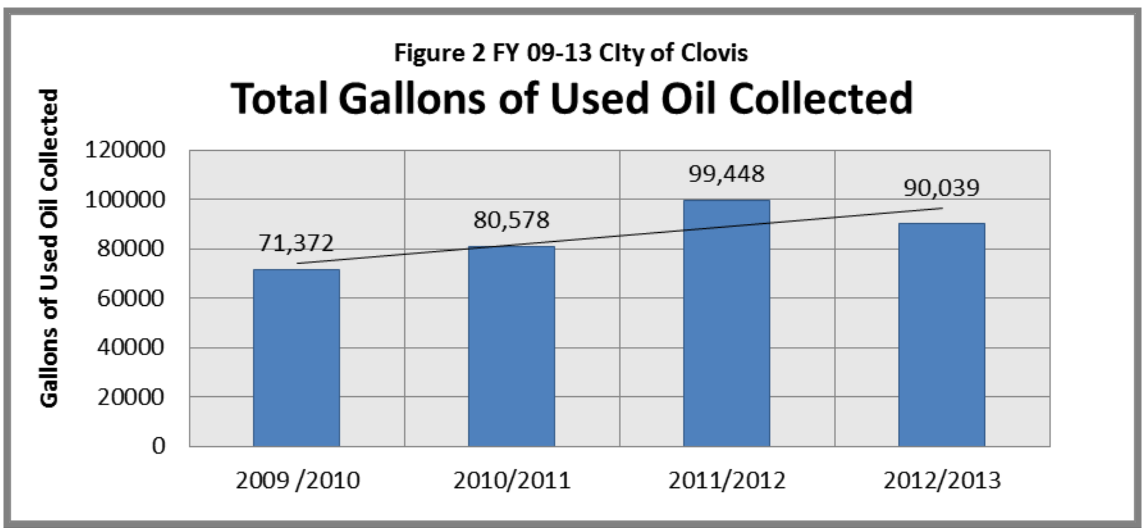
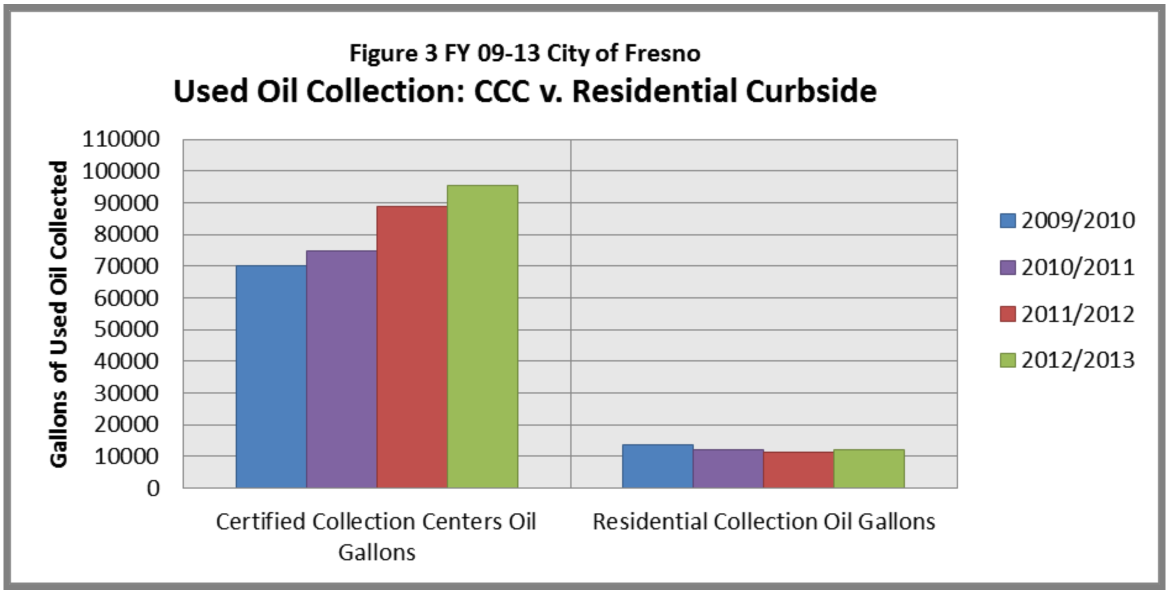
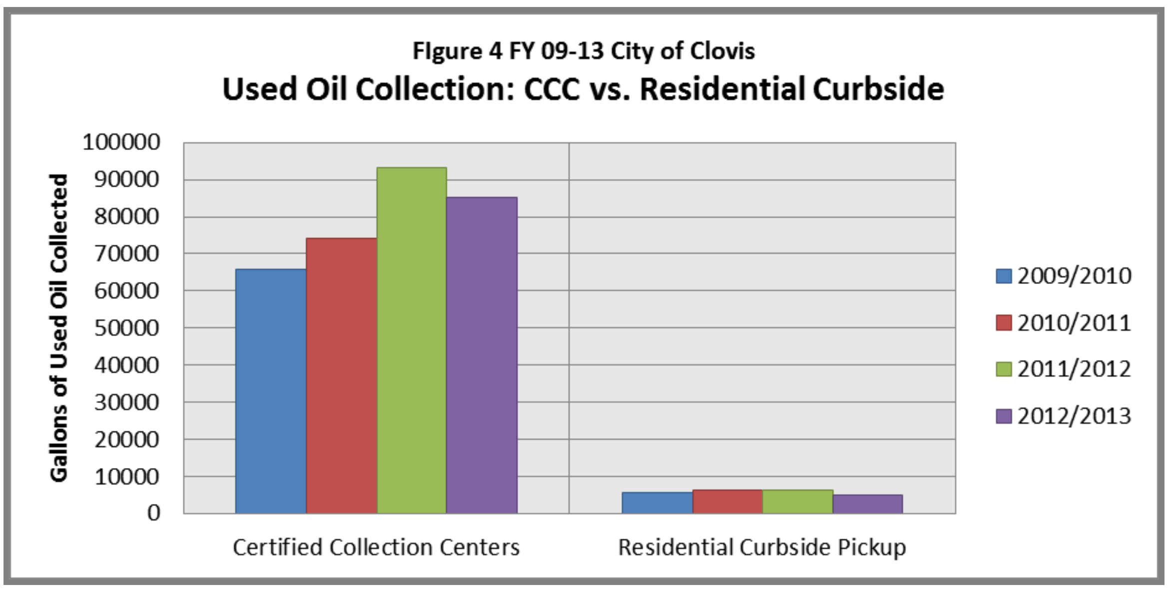


Figure 2 shows an increase of 39% from Fiscal Year 2009-2010 to Fiscal Year 2011-2012 for the City of Clovis. Overall, in the last four fiscal years, there was a total of 381,773 gallons of used oil collected from the City of Fresno and a total of 341,437 gallons from the City of Clovis.



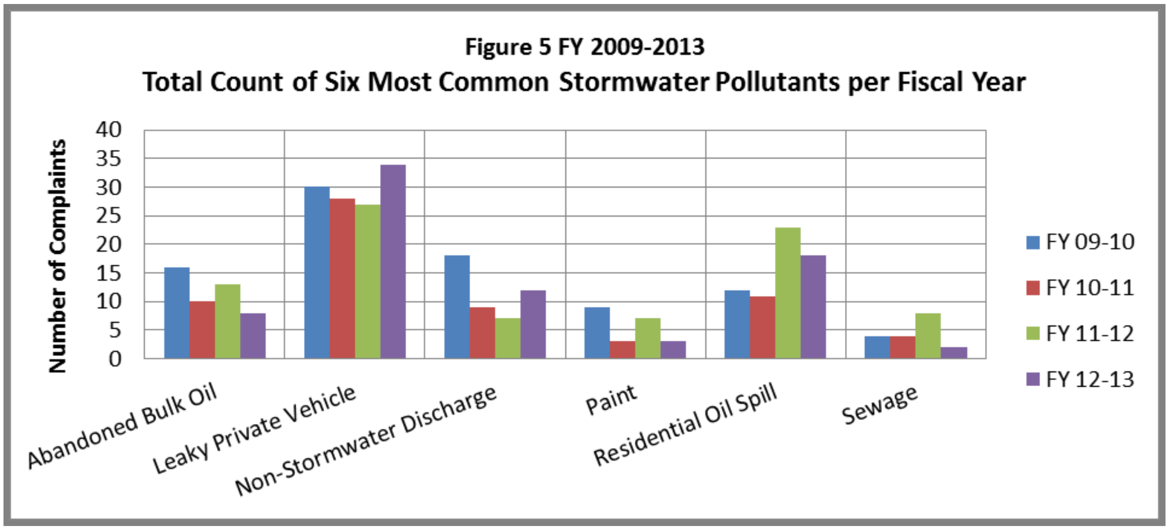
In Figure 3 and Figure 4, the amounts of used oil collected from Certified Collection Centers (CCCs) and the City of Fresno and City of Clovis Residential Curbside Collection Programs are compared over the last four fiscal years. CCCs are clearly the primary mechanism for used oil collection. However, the Residential Curbside Collection Programs provide residents who might not have the time to take the used motor oil to a CCC a convenient alternative method for properly disposing of used motor oil.





As shown in Figure 5, between the 2009 and 2013 fiscal years, leaky private vehicles were the type of stormwater incident most investigated by the cities. The number of leaky private vehicle incidents decreased slightly between 2009-2010 and 2011-2012 but increased in the 2012-2013 fiscal year. Residential oil spills also had an overall increasing trend, although the number of these types of incidents decreased between 2011-2012 and 2012-2013.

Two stormwater pollutant sources, abandoned bulk oil and paint, exhibited a decreasing trend. The data for abandoned bulk oil correlate with an increase in the collection of used motor oil by the two cities. The decrease in paint complaints could be a result of many years of public outreach, the availability at HHW collection events, and the relatively new paint manufacturer product responsibility programs, such as Paint Care. This type of information could be used to verify increases in awareness and behavior changes, as well as to adapt or guide future used motor oil outreach efforts.



Assessment Result

Actual Outcome: A total of 381,773 gallons of used motor oil collected in the City of Fresno and a total of 341,437 gallons in the City of Clovis, correlating to a downward trend in illicit discharge complaint investigations.

Targeted Outcome: An increase in the collection of used motor oil and a decrease in the number of illicit discharge complaints associated with abandoned used motor oil.

Assessment Result: The availability of convenient used motor oil disposal options for City residents could be responsible for the decreasing trend in illicit discharge complaints involving abandoned used motor oil.

Next Steps

Co-Permittees will continue their baseline used motor oil outreach campaigns, as determined by their individual used motor oil budgets. The stormwater programs will continue to promote the proper disposal of used motor oil, respond to and track illicit discharges, and evaluate trends.

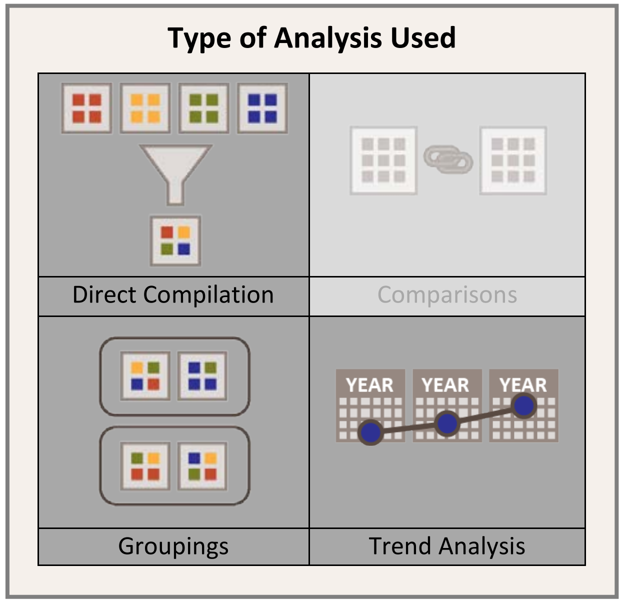
Source: *2004-05, Fresno/Clovis Storm Water Quality Management Program Annual Progress Report - Section 1- Public Education and Involvement. For more information contact FMFCD at info@fresnofloodcontrol.org*

I/C Industrial/Commercial Program Element

Compliance rates observed during inspections and the need for and results of follow-up inspections are the most often used tools to assess target audience actions for Industrial/Commercial programs.

Project

Palo Alto Regional Water Quality Control Plan: Vehicle Service Facilities



One element of Palo Alto's pollution prevention program is the Clean Bay Business Program targeting vehicle service facilities. For a vehicle service facility to qualify as a Clean Bay Business it must comply with the City's ordinance and implement a variety of BMPs. Compliance with each of the 15 ordinance requirements (each requirement is a BMP) has been tracked between 1992 and 1997. A business qualifies as a Clean Bay Business if it is in complete compliance on its first annual inspection (i.e., no follow-up inspection required) and it has no discharge limit violations.

- In the first year156 businesses (48%) were in complete compliance and 131 businesses (40%) qualified as Clean Bay Businesses.
- By 1997, all 303 vehicle service shops were in complete compliance and 21 of 23 fleet maintenance facilities were in complete compliance. In addition, 277 businesses (92%) qualified as Clean Bay Businesses.

Assessment Result

Actual Outcome: Within 5 years of implementing the Clean Bay Business Program for vehicle service facilities, almost 100% of the facilities were in compliance. The number of businesses qualifying as Clean Bay Businesses more than doubled in the 5 year period.

Targeted Outcome: no information

Assessment Result: The ordinance requirement and inspection program have been effective strategies for getting vehicle service facilities to implement BMPs.

Next Steps

This information can be used to inform other efforts to work with small businesses. In addition, with the apparent success of the program, the City could explore ways to measure results at higher outcome levels. The City can also determine if this program can be implemented at a maintenance level to allow shifting of resources to other water pollution issues.

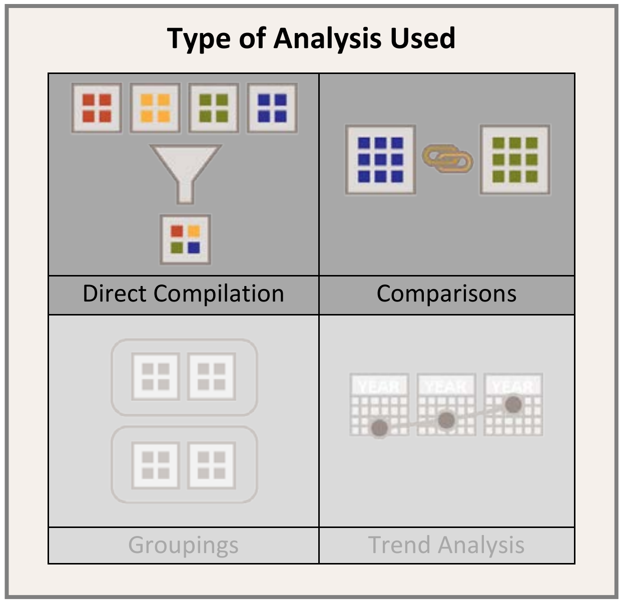
Source: *Water Environment Research Foundation, 2000. Tools to Measure Source Control Program Effectiveness. WERF Project 98-WSM-2. For more information go to http://www.werf.org or www.cityofpaloalto.org/public-works/cb-auto.html*

M Municipal Program Element

Many control measures of a municipal program can be assessed through inspections. Compliance rates observed during inspections/audits and the need for and results of follow-up inspections are the most often used tools.

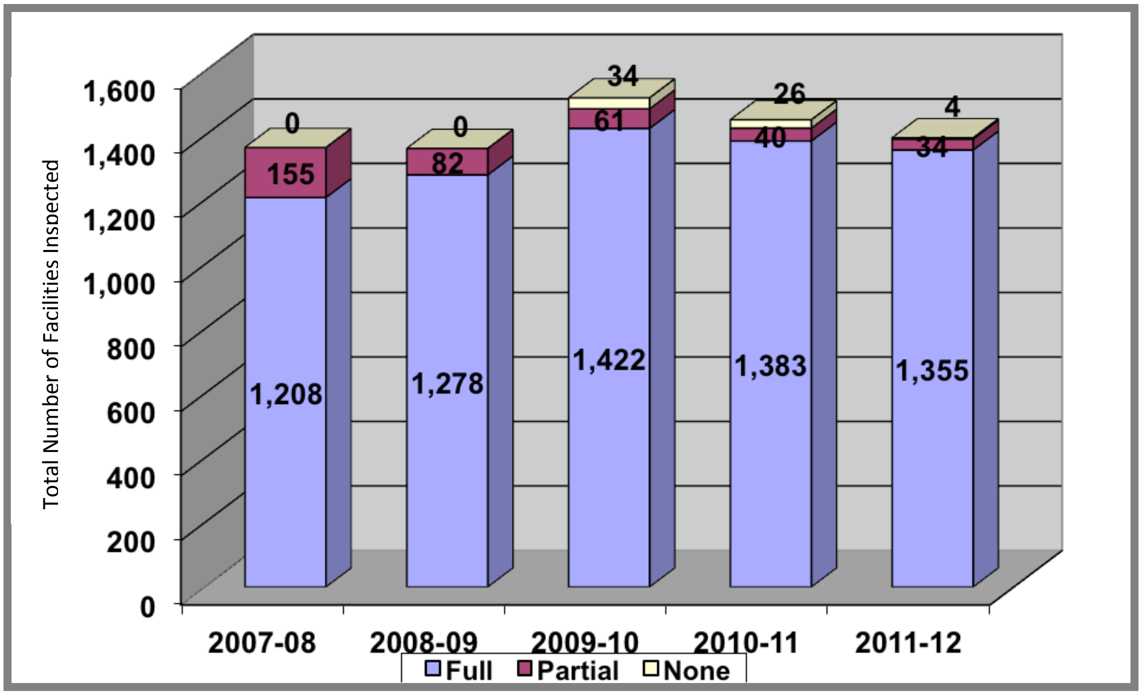
Project

Orange County Stormwater Program: Municipal Facilities Inspections



The Santa Ana Region municipal stormwater permit requires the Permittees to ensure that, through a systematic process of evaluation, BMPs are incorporated into municipal facilities and infrastructure maintenance programs. The Model Municipal Activities Program was developed and implemented in 2002-03. It established a framework for conducting a systematic program of evaluation and BMP implementation targeting fixed facilities/areas, field programs/activities and drainage facilities. The key findings of this program have been:

- The facilities and areas have been inventoried:
  - 1,762 facilities/areas have been reported as inventoried and are subject to the Program
- The facilities are inspected to ensure that the BMPs are being implemented:
  - In 2011-2012, 1,393 municipal facilities were reported as having been inspected for stormwater issues (compared to 1,449 in 2010-11; 1,517 in 2009-10; 1,360 in 2008-09; 1,363 in 2007-08)
- At the end of the 2011-12 reporting period, 1,355 municipal facilities were determined to have full BMP implementation(compared to 1,383 in 2010-11; 1,422 in 2009-10; 1,278 in 2008-09; 1,208 in 2007-08)



Levels of BMP Implementation

Over time the compliance has improved among the facilities indicating that the staff is aware of the BMPs that should be implemented and are implementing them. Tracking this information allows the County staff to evaluate the facilities and activities to determine where the resources should be focused during the next fiscal year.

Assessment Result

Actual Outcome: The number of facilities with no or partial implementation of BMPs has decreased from 155 in 2007-08 to 38 in 2011-12, a decrease of 75%.

Targeted Outcome: no information

Assessment Result: Overall BMP implementation rates among inspected facilities are very high with 89% of facilities having full implementation of BMPs in 2007-08 and 98% having full implementation in 2011-12. Efforts to reduce partial and no implementation of BMPs have also been effective.

Next Steps

This information is used to evaluate the facilities and activities to determine where resources should be focused. If there are BMPs that are commonly not implemented this could be one area to focus on. Strategies used to get full implementation of BMPs by municipal facilities could inform efforts to get commercial/non-municipal facilities to implement BMPs. The rate of BMP implementation over time could be used to set a targeted outcome (i.e., somewhere between 89 % and 97%).

Source: *Unified Annual Report, Section 6 Municipal Operations. For more information visit the Orange County website www.ocwatersheds.com and go to "Stormwater Program"*

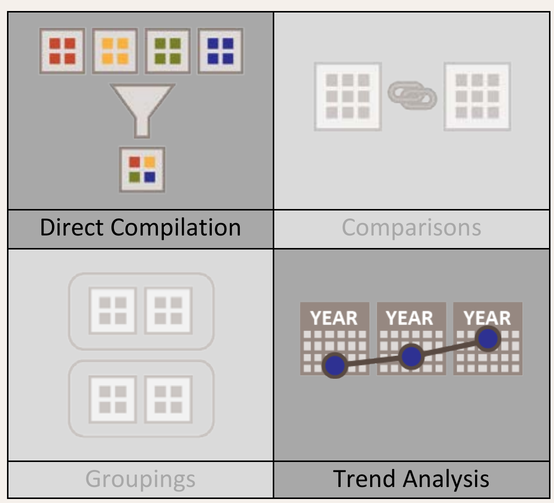
Project

City of Stockton: Field Crew Inspections

Illicit discharges are detected via several mechanisms including field crews who act as the "eyes and ears" of the stormwater program and identify illicit discharges while they are conducting their daily activities. Outcomes for the City of Stockton ID/IC program include:

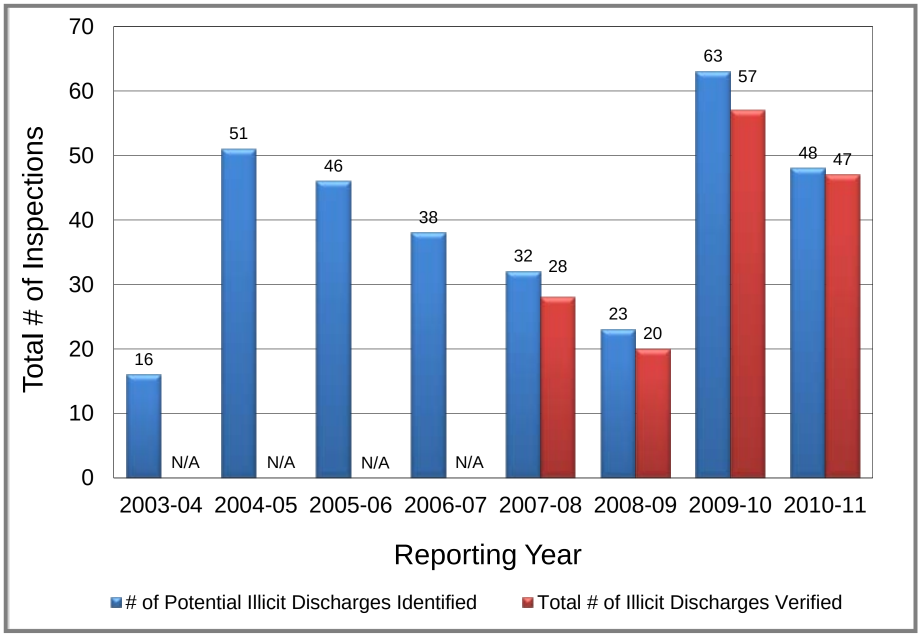
- Since 2003, 317 potential IDs have been identified.
- Since 2003-2004, the field crews have become more aware of what

Type of Analysis Used



constitutes an ID and have progressed from reporting incidents that may not have been problematic to reporting IDs that are verified in the field and addressed.

• The success rate of the field inspectors has increased in recent years (from 88% in 2007-2008 to 98% in 2010-2011).



Field Crew Inspections: Illicit Discharges Identified and Verified

Assessment Result

Actual Outcome: The number of illicit discharges identified more than doubled between 2008-09 and 2009-10. The % verified increased from 88% in 2008-09 to 98% in 2010-11.

Targeted Outcome: no information but 95-98% would be a reasonable target for percent of illicit discharges that are verified.

Result

Assessment Result: Training of inspectors has resulted in an increase in proportion of illicit discharges that are verified indicating that the training has been very effective. It is possible that the training is also the reason for the substantial increase in illicit discharges identified.

Next Steps

This information can be used to evaluate training. In addition, the 2009-10 values could be used as a baseline to measure effectiveness in reducing the total number if illicit discharges. Attention can be turned from training inspectors on identification to implementing strategies for education and enforcement that will result in the target audience reducing the number of illicit discharges.

Source: *June 2012 City of Stockton and County of San Joaquin NPDES Municipal Stormwater Program Report of Waste Discharge and Proposed Stormwater Management Plan. Section 3 Illicit Discharges. For more information visit the City of Stockton website* *http://www.stocktongov.com/government/departments/municipalUtilities/utilStorm.html*

2 Barriers & Bridges to Action

Level 2 outcomes measure the knowledge and awareness that a target audience has regarding a particular subject. These outcomes are critical since they ultimately form the basis for achieving desired behavioral changes and provide a means of gauging progress toward, or barriers to, their achievement. Level 2 Outcomes provide program managers with feedback on how effective various control measures have been in raising awareness and changing attitudes of the target audiences.

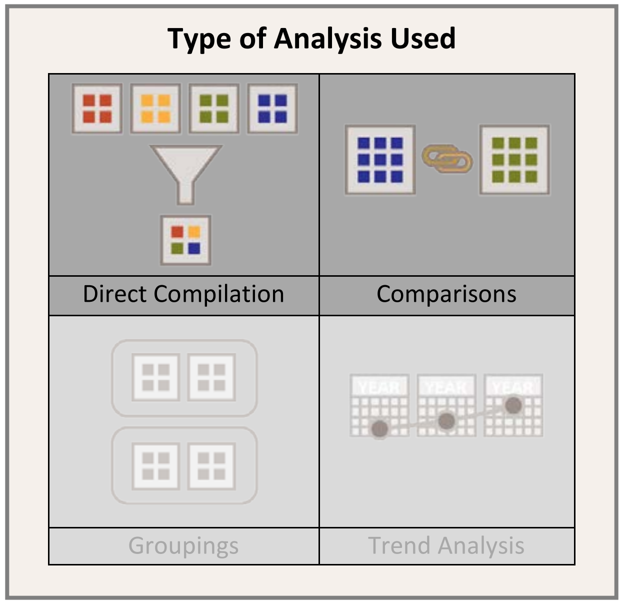
PE Public Education Program Element

Surveys are commonly used to assess awareness of the residential target audiences regarding stormwater issues. Repeating the same survey questions over time can show changes in public awareness that may be attributed to a stormwater program's efforts.

Recall of specific outreach materials can also be an indicator that the program efforts have resulted in increased awareness.

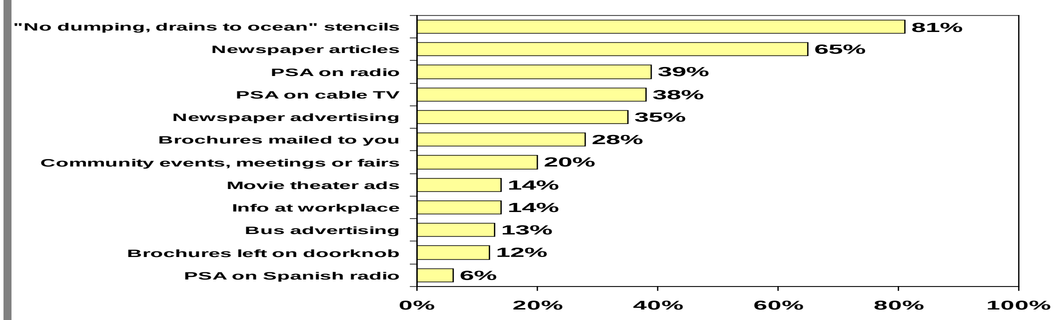
Project

Orange County Stormwater Program: Public Awareness Survey



The Santa Ana Region municipal stormwater permit requires Permittees to measurably increase the knowledge of target communities. On behalf of the 34 co-permittees, the County of Orange developed an approach and methodology for the program's public awareness surveys to measure changes in knowledge and behavior. In May 2003, 1,500 respondents were surveyed. This survey was repeated in November 2005. The second survey assessed whether public awareness had changed and if the residents made any behavior changes as a result of the campaign. Some of the key findings include:

- Knowledge about urban runoff and storm drains increased. 90% of the residents know that water flowing in the street enters a storm drain and goes directly to a waterway.
- Respondents were asked if items such as oil, styrofoam cups, pet waste, water from hoses, etc. contributed to polluting urban runoff. The survey results showed a strong upward trend regarding knowledge of pollutant sources and indicated that the educational materials and messages that have been developed to address specific pollutants are reaching the residents.
- The survey asked questions related to the effectiveness of the media outreach program in order to identify those aspects of the program that are recalled the most. The most effective mechanism reported and recalled were the storm drain stencils (81%) followed by newspaper articles (65%) and public service announcements on the radio (39%).



Public Awareness Survey Results

Assessment Result

Actual Outcome: 90% of residents know that water that water flowing in the street enters a storm drain and goes directly to a waterway. Outreach mechanisms that were most frequently recalled included storm drain stencils, newspaper articles and PSAs on the radio.

Targeted Outcome: no information

Result

Assessment Result: These results indicate that public outreach efforts are effective and identified the most effective mechanisms for outreach.

Next Steps

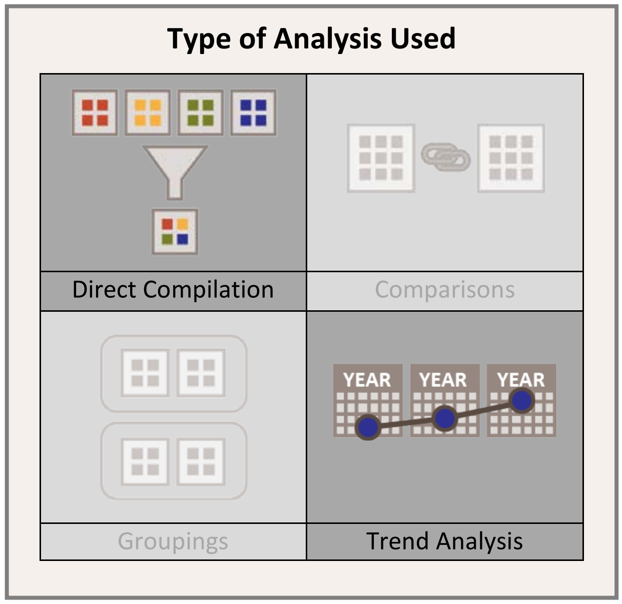
This information can be used to focus future resources on the most effective outreach methods and to determine if messages should focus on general outreach or more pollutant specific messages.

Source: *2005-2006 Unified Annual Report, Section 6 Public Education. For more information visit the Orange County website www.ocwatersheds.com and go to "Stormwater Program"*

Project

Orange County Stormwater Program: Incident Reporting

The Orange County municipal stormwater program has developed a telephone and web-based reporting system for the general public to report illicit discharges and illegal connections. The phone number and web page are also advertised in the public education materials, the Orange County "White Pages" telephone directories, and the 34 individual Permittee websites.



The program tracks awareness and, in part, target audience actions by identifying the number of complaints that are received. Although the number of complaints is a function of the number of actual incidents and the advertisement of the number and website, it can serve as an indicator for general public awareness regarding what constitutes an illicit discharge or an illegal connection and why it is important to report them. A summary of the program from 2003-2006 is provided below:

- 2005-2006 – 4,386 complaints/incidents reported
- 2004-2005 – 3,408 complaints/incidents reported
- 2003-2004 – 3,387 complaints/incidents reported

To provide additional insight for the overall effectiveness of the program this information can also be compared to the number of enforcement actions, specific education campaigns that have been conducted as well as the training of the inspectors.

Assessment Result

Actual Outcome: The number of complaint/ incidents reported more than doubled between 2002-2003 and 2005-2006.

Targeted Outcome: no information

Assessment Result: These results indicate that public outreach efforts are effective in educating the public regarding what constitutes an illicit discharge and why it is important to report them.

Next Steps

To provide additional information on program effectiveness, this information can be compared to the number of enforcement actions, specific education campaigns that have been conducted as well as the training of the inspectors. This could help to identify the most effective outreach methods and how well the public understands what constitutes an illicit discharge.

Source: *2005-2006 Unified Annual Report, Section10 Illicit Discharges/Illegal Connections. For more information visit the Orange County website www.ocwatersheds.com and go to "Stormwater Program" http://www.ocwatersheds.com/WQHotline/wqh_reporting.asp*

M Municipal Program Element

Assessment may be demonstrated by tracking actions taken by municipal staff. In addition, pre and post surveys at training sessions or workshops can also assess the understanding of target audience regarding the program requirements.

Project

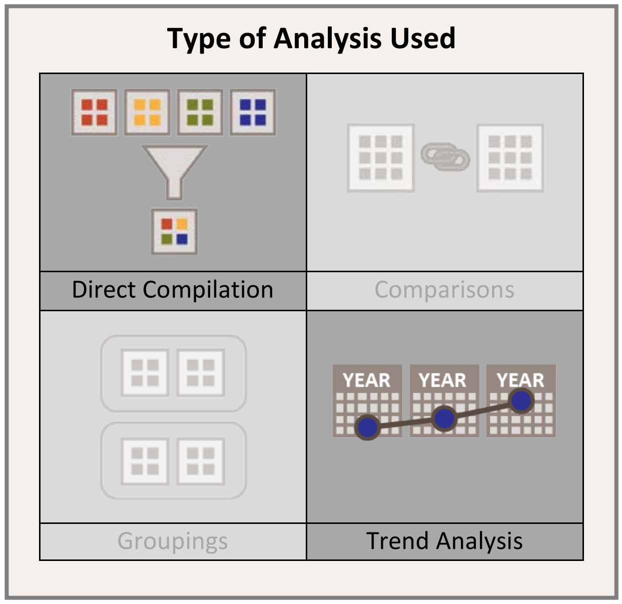
County of San Joaquin: Capital Improvement Projects

The San Joaquin County municipal stormwater program implements a comprehensive municipal operations program to ensure that the operations and maintenance activities are performed in a way that minimizes the pollutants generated.

As a part of the program they track a number of parameters to assist them in identifying if the program is increasing the awareness of municipal staff involved in the program.

One of the ways that they identify awareness is by tracking the implementation of the construction requirements for the municipal capital improvement projects.

The County requires that all capital improvement projects must be reviewed by stormwater staff to ensure that the construction BMPs and new development standards are incorporated during the design stage. As such, the County tracks the following:



- Total number of CIP plans reviewed
- Total number of CIP plans requiring revisions
- Total number of active public construction sites
- Total number of active public construction sites > one acre
- Total number of active public construction sites that submitted a Notice of Intent (NOI)

Some of the key findings include:

- Since 2003 all of the construction projects > one acre submitted a copy of the NOI.
- During 2004-2005 42% of the CIP plans reviewed required revisions. However, during 2005-2006 only 25% of the CIP plans reviewed required revisions.

These two measurements indicate that County staff involved in the design and construction of the County CIP projects increased their understanding of the program requirements and are implementing the necessary BMPs.

Assessment Result

Actual Outcome: CIP plans requiring revisions decreased 17% between 2004-2005 and 2005-2006.

Targeted Outcome: no information

Assessment Result: These results indicate that staff increased their understanding of program requirements.

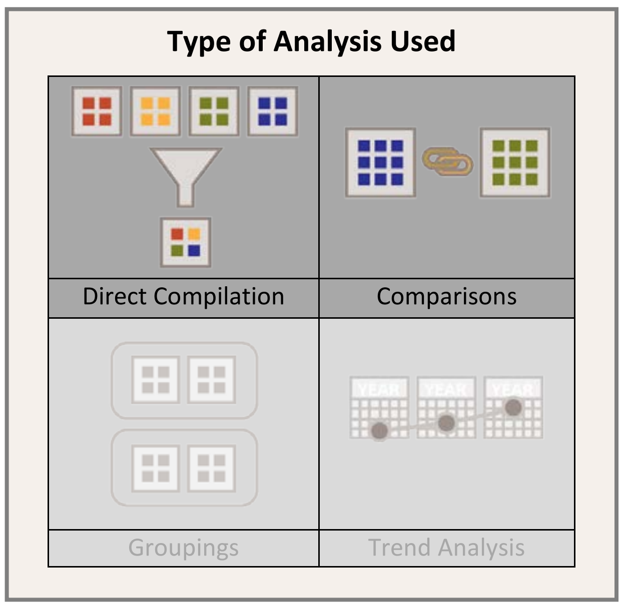
Next Steps

A review of the types of revisions that are still needed could help to focus future training efforts.

Source: *2005-2006 Annual Report, Section 4 Municipal Operations. For more information visit the County of San Joaquin website http://www.sjcleanwater.org*

Project

Orange County Stormwater Program: Inspector Training



The Orange County municipal stormwater program provides a number of training modules to the 34 co-permittees. One of the training modules is for the authorized inspectors who assist with the implementation of the ID/IC program. As a part of the training, pre- and post- surveys were provided to gauge the awareness of the inspectors before and after the training module. The key results from one of the training sessions indicated that the pre-training score was 66% correct, while the average post-training score was 81%. Overall, this demonstrates how the awareness of the attendees was increased during the training session.

One example of how the assessment data may be interpreted is:

- For questions where the % difference does not change significantly between the pre- and post- survey – This may indicate that, during the next training session, the speakers may need to spend additional time on these topics in order to increase the understanding.
- For questions where the % difference does change significantly – This may indicate that these questions were appropriately covered during the training session and at the right difficulty level.
- For questions where the pre-survey results are very high – This may indicate that the question is not at the right difficulty level and may need to be modified.

Based on the results of the surveys, the training modules and corresponding handouts and surveys can be updated so that they are more effective.

Assessment Result

Actual Outcome: Inspectors knowledge increased by an average of 15% as a result of training.

Targeted Outcome: no information

Assessment Result: The training module was effective in educating inspectors about ID/IC program implementation.

Next Steps

This information can be used to modify training modules to make sure topics are being covered effectively. Pre- and post-survey results can be used to identify topics that are not covered sufficiently (no significant change in survey results), topics that are covered well (significant change in survey results), topics that don't need to be covered or questions that need to be modified(pre-survey score very high).

Source: *For more information visit the Orange County website www.ocwatersheds.com and go to "Stormwater Program"*

8.6 STORMWATER MANAGEMENT PROGRAM COMPONENT

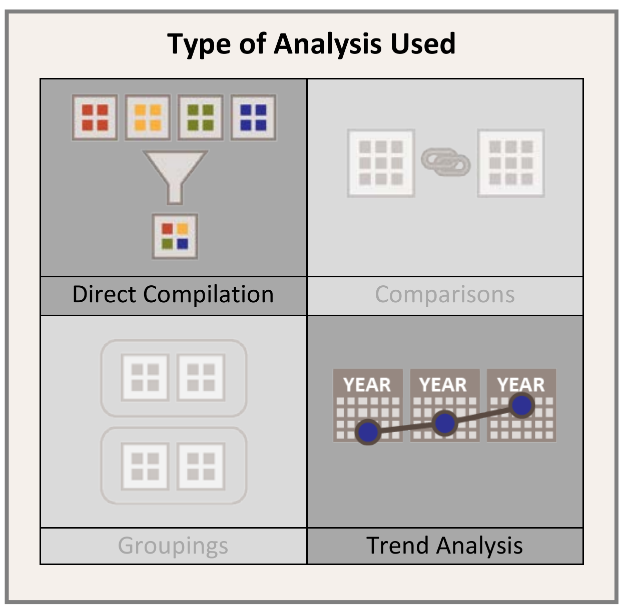
Stormwater Management Program Component

1 Stormwater Program Activities

Level 1 assessment measures are often explicitly defined by permit requirements (minimum inspection frequencies for construction sites or commercial facilities, annual updates to source inventories, etc.). However, where they are not explicitly included within the stormwater permit, managers must set their own assessment measures by interpreting the types and degrees of program activity that are necessary to achieve a satisfactory level of performance and, to what degree, they want to track each of these items. Level 1 Outcomes provide program managers with feedback on how well the development and implementation of the SWMP is progressing and whether targeted goals are being met.

C Construction Program Element

Indicators of effectiveness for construction would include confirmation that construction inspections are being conducted and that BMP implementation, corrective actions, and training have been documented.



Project

Fresno-Clovis Stormwater Quality Management Program (SWQMP): Inspection Tracking

The Fresno Metropolitan Flood

Control District (District) developed and maintains a database to document the construction inspections. As a part of the program, they track:

- Number of inspections;
- Number of permit violations; and
- Number of corrective actions.

The District uses the data to modify training programs and public outreach campaigns according to the types and frequency of the inspection problems observed.

The District also maintains a construction training base database that not only tracks the training sessions conducted, but also has participant contact information that is used for regulation updates and training announcements.

- Over 228 people, including developers, site superintendents and city agencies attended the District's construction training courses in fiscal year 2005-06 (this was a 63 % increase from FY 2004-05).

Assessment Result

Actual Outcome: The number of people receiving training increased 63% between 2004-2005 and 2005-2006.

Targeted Outcome: no information

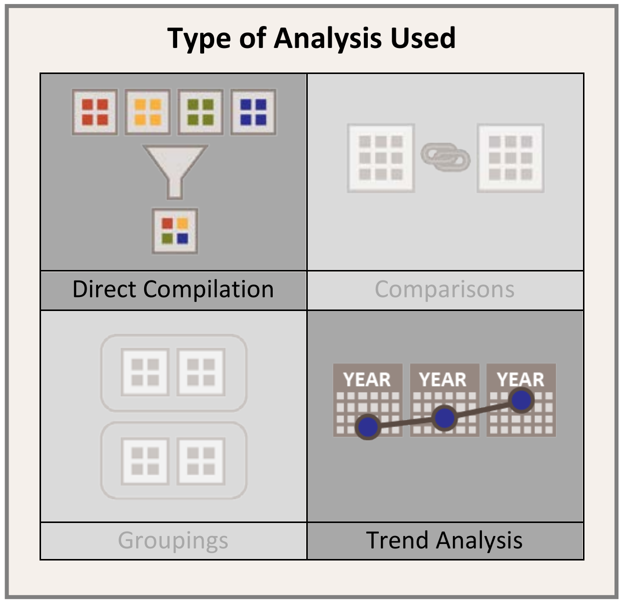
Assessment Result: These results indicate that training is being conducted for more people.

Next Steps

The number of people trained could be compared to the number of people that should receive training to determine if training programs need to be expanded or continued at the current rate.

Source: *2005-06, Fresno/Clovis Storm Water Quality Management Program, Annual Progress Report - Section 5- Construction and Development. For more information contact FMFCD at info@fresnofloodcontrol.org*

PE Public Education Program Element



Indicators of effectiveness for public education and outreach include tracking the number of impressions, tracking the number of brochures distributed, hits to the program website, and/or the number of volunteers marking storm drains.

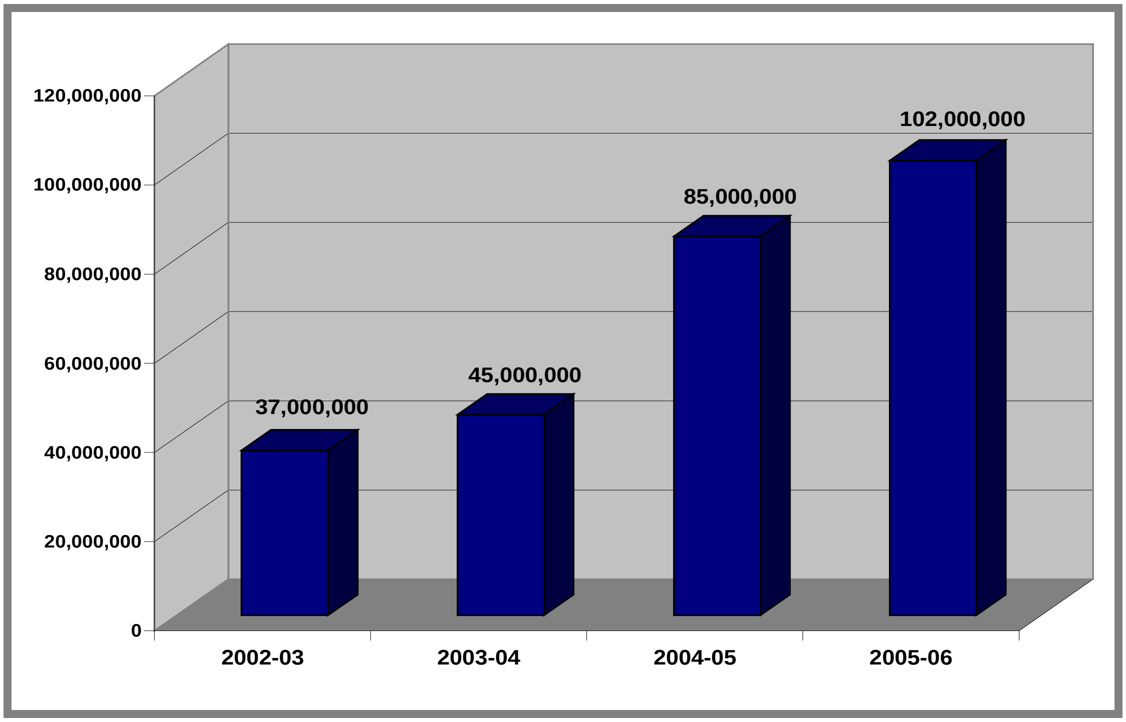
Project

Orange County Stormwater Program: Impression Tracking

The Santa Ana Region municipal stormwater permit requires the Permittees to target 100% of the residents, including businesses, commercial, and industrial establishments. Through the use of the local print, radio, and television, the Permittees must ensure that the public and business education program makes a minimum of 10 million impressions per year in the Santa Ana Regional Board area.

The Principal Permittee (the County of Orange) took the lead in developing and implementing a regional public education program on behalf of the 34 co-permittees. The regional program includes a media outreach campaign to reach a majority of the selected target groups. The media plan includes print, internet, bus, theater, cable, and radio advertising. The County also developed and implemented a non-media outreach plan which includes outreach materials for the co-permittees, business outreach, utility outreach, and media relations.

The countywide public education program created approximately 102 million impressions during 2005-2006, which was a 20% increase over the number of impressions created during the 2004-2005 time period. The public education program was developed, implemented and far exceeded the permit requirement of the 10 million impressions.



Number of Impressions

Assessment Result

Actual Outcome: The public education program created 37 million impression in 2002-03. This has increased to 102 million impressions over time.

Targeted Outcome: 10,000 million impressions

Assessment Result: The number of impressions regularly exceeds the targeted outcome and increased by a factor of approximately 2.5 over 4 years.

Next Steps

This information is used to indicate that the public education program is being implemented as required. This would indicate that there should be the information available to evaluate program effectiveness at higher outcome levels.

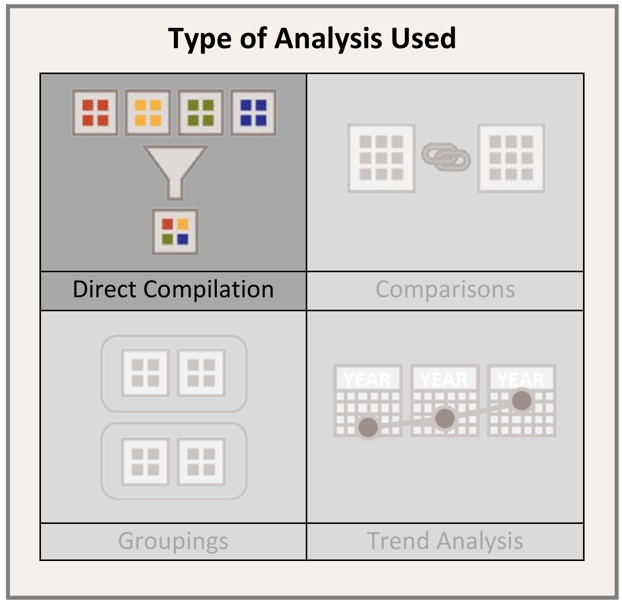
Source: *2005-2006 Unified Annual Report, Section 6 Public Education. For more information visit the Orange County website www.ocwatersheds.com and go to "Stormwater Program".*

I/C Industrial/Commercial Program Element

Indicators of effectiveness for industrial/commercial would include tracking the number of BMPs incorporated, or the number of sites inspected.

Project

County of Sacramento: Inspection Tracking



The Environmental Management Department (EMD) implements the County's industrial inspection program and has developed a database to track the implementation. Some of the results include:

- Conducted 385 inspections in Fiscal Year 2004-05
- Conducted 777 inspections in Fiscal Year 2005-06
    - Issued approximately 361 Notices of Violation
    - Handed outreach material to almost all business owners/operators during the inspections

EMD held two training classes where approximately 80 Sacramento County business operators/owners attended during the Fiscal Year 2005-06. In addition, the Business Environmental Resources Center (BERC) assisted 24 City of Sacramento businesses with stormwater related issues.

Assessment Result

Actual Outcome: The number of inspections conducted doubled between 2004-2005 and 2005-2006.

Targeted Outcome: no information

Assessment Result: EMD is conducting inspections and training to implement its program and reaching an increasing number of industrial facilities.

Next Steps

This information indicates EMD is utilizing a variety of strategies (inspections, training, resource center) to implement its industrial program. Comparison to the total number of industrial facilities in the service area would provide an indication of the portion of the target audience that is reached.

Source: http://www.emd.saccounty.net/EnvHealth/Stormwater/Stormwater.html

M Municipal Program Element

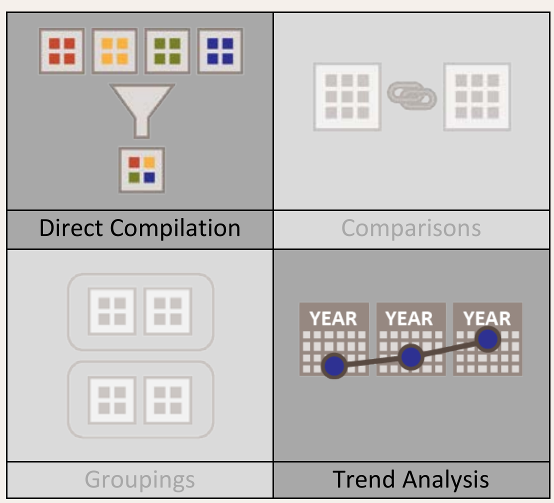
Indicators of effectiveness for municipal operations would include confirmation that guidance has been developed, numbers and types of BMPs that are being implemented, and/or training sessions that have been conducted.

Project

California Department of Transportation (Caltrans): Training Program

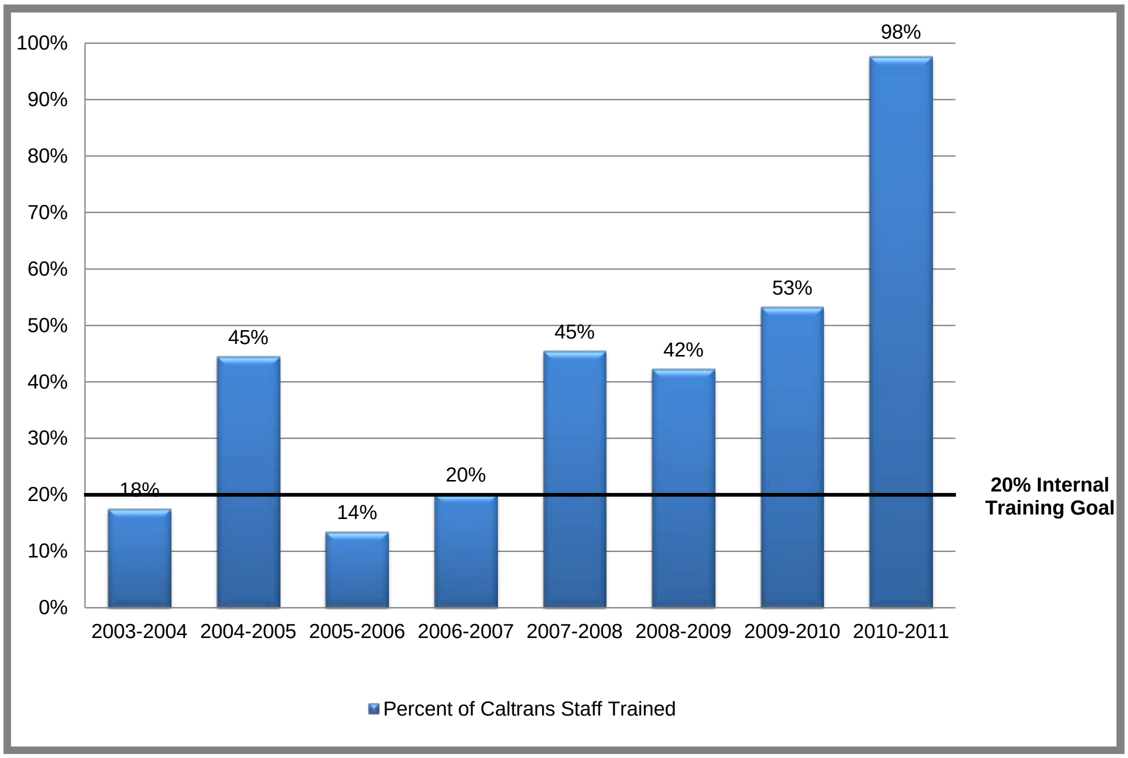
The training program goal is to train 20% of the Caltrans staff involved in stormwater during each fiscal year, with the entire staff trained over a five-year term. Both goals have been met.

Type of Analysis Used



Within the Division of Construction the following conclusions were noted:

- Eleven (11) training courses were provided to 2,930 employees (98% of staff).
- The focus of the courses included field applications, inspection procedures, dewatering operations, water quality sampling, water quality sampling and analysis, and elements of the SWPPP.
- Since 2003-2004, on average, 41% of the employees have been trained each year (some multiple times).



Construction Employee Training: Percent of Staff Trained by Fiscal Year

Assessment Result

Actual Outcome: Since 2007, 45% to 98% of staff have been trained annually. In 2010-11, eleven training course were offered resulting in training 98% of staff.

Targeted Outcome: Train 20% of staff each fiscal year to result in training all staff every 5 years.

Assessment Result: Caltrans has exceeded it training goal every year since 2007.

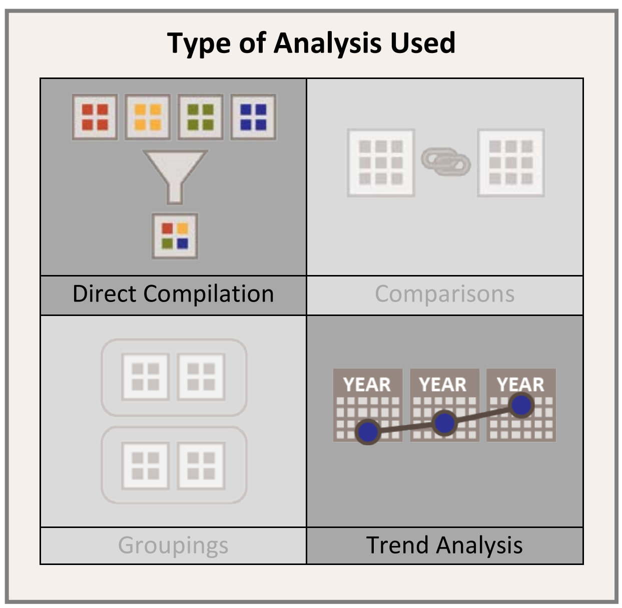
Next Steps

This information can be used to demonstrate that CalTrans is meeting its training goals. This would indicate that evaluation at higher outcome levels (particularly Levels 1 and 2) should be possible.

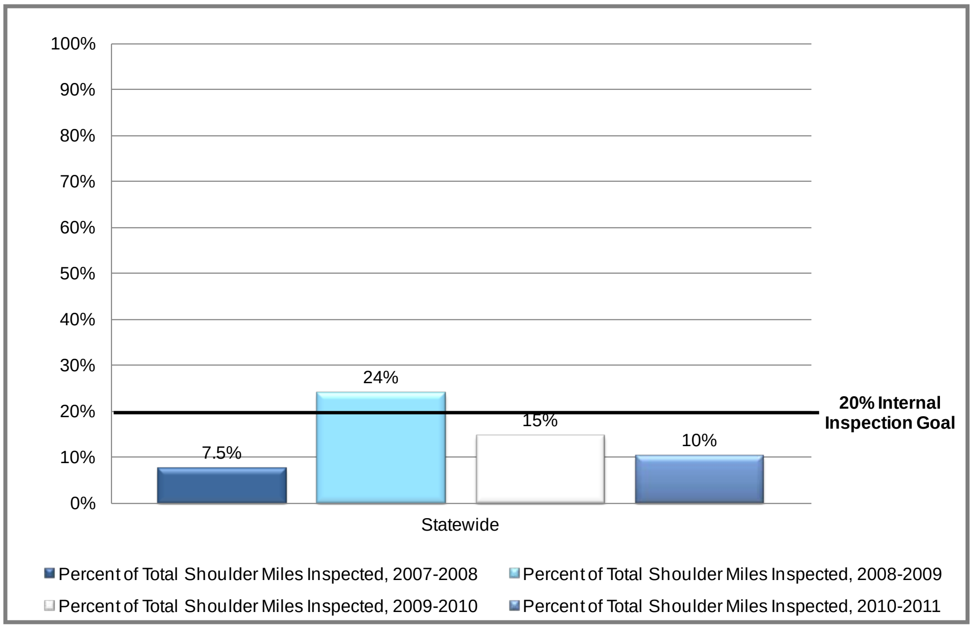
Source: *April 2013 California Department of Transportation Statewide Stormwater Management Program Annual Report Fiscal Year 2011-2012. Chapter G Program Effectiveness Assessment. For more information visit the Caltrans website http://www.dot.ca.gov/hq/env/stormwater/annual_report/curent_ar.pdf*

Project

California Department of Transportation (Caltrans): Vegetated Slope Inspections



Caltrans' Division of Maintenance has an ongoing program to inspect roadside vegetated slopes for erosion. The division has a self-imposed goal to inspect approximately 20% of the slopes in each District annually depending on weather conditions and work load priorities. The objective is to meet the SWMP requirement within the five-year period, even though there may be fluctuations in the actual percentage of inspections completed. Statewide, the program goal was met some years and not others. During the assessment of this program, the goal may be revisited to see if it should be modified.



Slope Inspection: Percent of Shoulder Miles Inspected, Statewide

Assessment Result

Actual Outcome: Percent of shoulder miles inspected has ranged from 7.5% to 24%.

Targeted Outcome: Inspect 20% of slopes each fiscal year to result inspecting all slopes every 5 years.

Assessment Result: Caltrans has met this goal once since 2007-2008.

Next Steps

This information can be used to determine if the goal is realistic and if there are factors (e.g., weather, resources) prevent this goal from being achieved. Whether adequate information is obtained from the current inspection rate could also be evaluated.

Source: *April 2013 California Department of Transportation Statewide Stormwater Management Program* Annual Report Fiscal Year 2011-2012. Chapter G Program Effectiveness Assessment. For more information *visit the Caltrans website* *http://www.dot.ca.gov/hq/env/stormwater/annual_report/curent_ar.pdf*

Attachment A
Glossary of Acronyms and Terms

303d listing: The 303(d) list is the priority list of impaired water bodies established under the Clean Water Act Section 303(d)(1)(A). The list is of impaired water bodies in which water quality does not meet applicable water quality standards and/or is not expected to meet water quality standards, even after the application of technology based pollution controls required by the Clean Water Act.

Adaptive Management: Adaptive Management is a structured and iterative process of directing decision-making with an aim toward addressing and reducing uncertainty over time. It's been described as "learning to manage by managing to learn."

Assessment Measures: Assessment measures are established to determine current conditions, or whether or how successfully an outcome has been achieved. Measures may be qualitative (e.g., yes / no) or quantitative (% of targeted audience reached, % reduction in a constituent level, etc.). All priority Outcomes should have at least one Assessment Measure associated with them, but some may have more than one.

Assessment Methods: Assessment methods are program activities, actions, or processes used to obtain or to evaluate assessment data or information. Depending on the particular outcome in question, numerous assessment methods may be possible.

Assessment Outcome: Outcomes are end results associated with the implementation of stormwater control measures, program activities or elements, or overall programs. They define specific measurement points to which stormwater programs can be targeted, evaluated, and periodically modified. Outcomes can be broadly categorized according to six Outcome Levels.

Barrier to Action: A barrier to action is an influencing factor that may prevent practices that are protective of water quality.

Basin Plan: Basin Plans designate beneficial uses and establish water quality objectives for waters of the State. For waters within a specified area, a basin plan designates or establishes: (1) beneficial uses to be protected; (2) water quality objectives; and (3) a program of implementation to achieve the water quality objectives (Water Code §13050).

Metrics: metrics are the expression of changes in unambiguous terms. They include a specific formulation of the outcome statement, the assignment of units of measure or assessment, and units of time.

Beneficial Use: Beneficial uses are the designated uses of a waterbody. Water Quality Control Plans (or Basin Plans) designate beneficial uses and establish water quality objectives for waters of the State.

Benthic Impairment: "Benthic" refers to the aquatic organisms living in or on the bottom of a body of water. Benthic organisms include crayfish, aquatic snails, clams, leeches, aquatic worms, certain insect larvae and nymphs (e.g., mayflies, dragonflies), and adult aquatic insects (e.g., riffle beetles). Changes in water quality generally result in changes in the types, numbers, or diversity of the benthic community. In general, water quality "impairment" exists if a body of water does not support its designated uses. The benthic macro invertebrate community present in a body of water is periodically evaluated to determine if a benthic impairment exists.

Best Management Practices (BMP): Best management practices (BMPs) are practices designed to prevent, reduce, or eliminate discharges of pollutants and flow.

Bio-indicator: Biological indicators are species that can be used to monitor the health of an environment or ecosystem. They are any biological species or group of species whose function, population, or status can reveal what degree of ecosystem or environmental integrity is present.

Bridge to Action: A bridge to action is an influencing factor that may promote practices that are protective of water quality.

California Environmental Quality Act (CEQA): The California Environmental Quality Act is a statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible.

California Stormwater Quality Association (CASQA): CASQA has been a leader since 1989 when the field of stormwater management was in its infancy. CASQA's represents a diverse range of stormwater quality management organizations and individuals, including cities, counties, special districts, industries, and consulting firms throughout the state. A large part of CASQA's mission is to assist water quality programs in California to learn collectively from the individual experiences of its members, to learn from the mistakes and avoid the pitfalls. In fulfilling this purpose, CASQA recommends objectives and procedures for stormwater discharges control programs which:

- Are technically and economically feasible
- Provide significant environmental benefits and protect our water resources
- Promote the advancement of stormwater management technology
- Effect compliance with State and Federal laws, regulations and policies

CASQA has multiple subcommittees providing in-depth collaboration on water quality issues statewide. The Effectiveness Assessment Subcommittee has provided input and guidance on stormwater program effectiveness assessment issues since 2004.

Causation: Causation is the act or process of causing something to happen or exist.

Certainty: Certainty refers to the confidence with which a problem condition can be stated.

Co-Occurrence: Co-occurrence describes separate outcomes occurring in sequence or within the same period of time. It does not imply any form of relationship between outcomes, but may form a basis for further exploration.

Comprehensive Planning and Assessment Strategy: A comprehensive planning and assessment strategy will typically address a wide variety of individual outcomes, but their selection will ultimately reflect the specific details, priorities, and assessment objectives of each Stormwater Management Program.

Controllability: Controllability refers to the potential for a program to prevent or eliminate an identified problem condition.

Correlation: Correlation is similar to co-occurrence except that it involves some degree of statistical support. Once sufficient sample sizes are established, outcomes can be correlated.

Dry Weather Flow: Dry weather flow refers to the flow in a drainage system from over-irrigation that occurs during periods of dry weather.

Economic Impacts: Economic Impacts are essential considerations because every problem and every proposed solution has one or more costs associated with it. These costs can be associated with capital expenditure, long term maintenance, or lost opportunity, among others.

End-State Targets: End-state Targets are specific targets established for achieving end-state conditions. End-state conditions describe a "no problem" state. Once achieved, they can be considered to represent long-term success for the particular outcome under consideration.

Effectiveness Assessment: Effectiveness assessment is the mechanism by which feedback is evaluated to enable ongoing adaptive management. It evaluates the efficacy of management measures in meeting the interim and end-state targets that include reducing the receiving water impacts; lessening MS4 contributions and source contributions that lead to receiving water impacts; changing behaviors and breaking down barriers to these changes. Effectiveness assessment identifies where management measure refinements are required, utilizing the overarching planning process of this guidance to develop and perform outcome specific and integrated assessments and prioritize management measures.

Eutrophication: Eutrophication is the process by which a body of water becomes enriched in dissolved nutrients (as nitrates or phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen.

Facilitation Activities: Facilitation activities are those which bring about (or "facilitate") changes in target audiences. For example, a program manager seeking to increase BMP implementation by construction site workers might rely on facilitation activities such as training and inspections. Conversely, a residential program element might be focused on education, incentives, and waste collection to encourage pesticide use reduction or picking up after pets.

Flow Control BMPs: Flow control BMPs reduce discharge that can have a detrimental effect on receiving waters. Consequently, they are often designed for a higher range of storm sizes than treatment controls. Multiuse facilities can incorporate both flow control and treatment control BMPs.

Geographic Information System (GIS): A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

Hydromodification: Hydromodification is the change in the natural watershed hydrologic processes and runoff characteristics (i.e., interception, infiltration, overland flow, and groundwater flow) caused by urbanization or other land use changes that result in increased stream flows and sediment transport. In addition, alteration of stream and river channels, such as stream channelization, concrete lining, installation of dams and water impoundments, and excessive stream bank and shoreline erosion are also considered hydromodification, due to their disruption of natural watershed hydrologic processes.

Hypothesis: A hypothesis is a supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation.

Implementation Assessment: Implementation Assessment is the evaluation of the different activities that make up stormwater programs. It consists exclusively of Level 1 Outcomes (Stormwater Program Activities).

Influencing Factor: An influencing factor is anything that affects the behaviors of an individual or group.

Interim Targets: Interim Targets define an incremental pathway toward the achievement of longer-range goals. They assist in evaluating progress towards achieving End-state Behavioral Targets.

Iterative Program Management Cycle: The Iterative Program Management Cycle broadly divides stormwater program management into three phases of activity:

1. Program planning and modification;
2. Program implementation; and
3. Effectiveness assessment.

During the program planning phase, implementation and assessment results will be reviewed to identify necessary changes or refinements for future implementation. These modifications can then be made and the next round of implementation initiated, leading again to renewed assessment and planning.

Over time, the repeated application of this process – each phase continuously informing the next – should result in the improvement of stormwater programs and the achievement of the desired results that they are designed to achieve.

Low Impact Development: Low Impact Development (LID) is a storm water management and land development strategy that emphasizes conservation and the use of on-site natural features integrated with engineered, small-scale hydrologic controls to more closely reflect pre-development hydrologic functions.

Municipal Separate Storm Sewer System (MS4): A Municipal Separate Storm Sewer System (MS4) is a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) 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;
- Not a combined sewer; and
- Not part of a Publicly Owned Treatment Works (POTW) (sewage treatment plant).

Stormwater runoff is commonly transported through MS4s and often discharged untreated into local water bodies.

Nature: Nature describes what a problem is (e.g., elevated bacteria levels, overwatering, etc.). The nature of a receiving water condition describes its general characteristics or attributes.

Non-structural BMP: Non-structural BMPs are preventative actions that involve management and source controls. Non-structural BMPs are typically passive or programmatic and tend to focus on source control and pollution prevention; reducing pollution in runoff by reducing the opportunity for the stormwater runoff to be exposed to pollutants.

Outcome Level: The CASQA approach utilizes a series of six categories of Outcomes to establish a logical and consistent organizational scheme for assessing and relating individual Outcomes. Starting with Level 1 and moving sequentially toward Level 6, they represent a general progression of conditions that are assumed to be related in a sequence of causal relationships.

Outcome Level 1 (Stormwater Program Activities): These Outcomes, which are often defined by specific stormwater permit requirements, address a variety of stormwater program activities such as providing education to residents, inspecting businesses, conducting surveys of target audiences, and conducting receiving water monitoring.

Outcome Level 2 (Barriers and Bridges to Action): Level 2 Outcomes provide a means of gauging whether outreach, training, or other program activities are producing changes in the awareness, knowledge, or attitudes of target audiences. Examples of Level 2 Outcomes range from awareness of basic concepts (why stormwater pollution is a problem, the difference between storm drains and the sanitary sewer, what a watershed is, etc.) to very specific knowledge (e.g., how to dispose of pet waste, or how to properly install and maintain a silt fence). Level 2 Outcomes are often used to gauge progress in, or to refine approaches for, achieving Level 3 Outcomes.

Outcome Level 3 (Target Audience Actions): Level 3 Outcomes address the actions of target audiences, and whether or not changes are occurring in them over time. The major categories of target audience actions are pollutant-generating activities (PGAs); best management practices (BMPs) and supporting behaviors. Supporting behaviors include pollution reporting, public involvement, and completion of stormwater pollution prevention plans.

Outcome Level 4 (Source Contributions): Outcome Level 4 addresses two distinct but related types of change: 1) reductions in the discharge of pollutants from sources, and 2) reductions in flow rates and volumes from sites. This latter category is generally associated with selected development and redevelopment activities, but it may also be applied to other program components.

Outcome Level 5 (MS4 Contributions): Level 5 Outcomes apply exclusively to MS4s. Level 5 conditions may be measured within the MS4, or as discharges from it. In either case, evaluation typically focuses on flow conditions, pollutant concentrations or loads, or both. Level 5 Outcomes provide a direct linkage between upstream sources and receiving waters, and as such are a critical expression of program success.

Outcome Level 6 (Receiving Water Conditions): Level 6 outcomes describe receiving water conditions. They can apply either to existing conditions or to improvements that will be sought over time through program implementation. They can include virtually any chemical, biological, or physical parameter that can be measured or assessed in receiving waters (i.e., chemical concentrations, dissolved oxygen levels, biological integrity, species diversity, eutrophication, microbiological or toxicological conditions, hydromodification, or trash). Level 6 successes are best expressed through the attainment of beneficial uses, traditionally measured as compliance with water quality objectives (WQOs).

Outfall: Outfall means a point source as defined by 40 CFR 122.2 at the point where a municipal separate storm sewer discharges to waters of the US and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels or other conveyances which connect segments of the same stream or other waters of the US and are used to convey waters of the US.

PGA-BMP Packages: PGAs and BMPs in related groupings that are focused on common target audiences or source contributions. That is, each identified PGA for a particular target audience will have one or more BMP alternatives associated with it.

Phase I Area Wide MS4 Permit: Phase I, issued in 1990, requires medium and large cities or certain counties with populations of 100,000 or more to obtain NPDES permit coverage for their stormwater discharges. Generally, Phase I MS4s are covered by individual permits. Each regulated MS4 is required to develop and implement a stormwater management program to reduce the contamination of stormwater runoff and prohibit illicit discharges.

Phase II Permit: Phase II, issued in 1999, requires regulated small MS4s in urbanized areas, as well as small MS4s outside the urbanized areas that are designated by the permitting authority, to obtain NPDES permit coverage for their stormwater discharges. Generally, Phase II MS4s are covered by a general permit. Each regulated MS4 is required to develop and implement a stormwater management program to reduce the contamination of stormwater runoff and prohibit illicit discharges.

Pollutant-generating Activity (PGA): Pollutant-generating activities (PGAs) are the behaviors that contribute pollutants to runoff (i.e., rinsing off a sidewalk or other surface with material such as sediment, trash, or vegetation on it). PGAs are not necessarily the result of current human behaviors, they may also include pollutant-generating features that may be the result of past behaviors (e.g., erosion from past road design and construction). For simplicity, the term PGA will be used to describe both the existing features and current activities in a watershed that generate pollutants.

Program Effectiveness Assessment: The methods and activities that stormwater managers use to evaluate how well their programs are working, and to identify modifications necessary to improve them.

Receiving Water Characterization: Receiving water characterization consists of three tasks: evaluating receiving water conditions, defining receiving water problems, and prioritizing receiving water problems.

Receiving Water Conditions: Receiving water conditions can include virtually any chemical, biological, or physical parameter that can be measured or assessed in receiving waters (i.e., chemical concentrations, dissolved oxygen levels, biological integrity, species diversity, eutrophication, microbiological or toxicological conditions, hydromodification, or trash).

RWQCB: There are nine Regional Water Quality Control Boards (Regional Boards). The mission of the Regional Boards is to develop and enforce water quality objectives and implementation plans that will best protect the beneficial uses of the State's waters, recognizing local differences in climate, topography, geology and hydrology. Each Regional Board has nine part-time Members also appointed by the Governor and confirmed by the Senate. Regional Boards develop "basin plans" for their hydrologic areas, govern requirements/issue waste discharge permits, take enforcement action against violators, and monitor water quality.

Section 401 Water Quality Certification: This refers to Section 401 of the Clean Water Act. Activities subject to this type of permit include any activity that would result in the placement of structures or dredged or fill materials into waters of the state, which generally encompass waters of the United States.

Section 404 Permit: This refers to Section 404 of the Clean Water Act, which establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g. certain farming and forestry activities).

Significance: Significance is the importance or meaning of something, in this case a problem condition. Determinations of significance will normally reflect the nature, magnitude, and prevalence of the condition. Nature describes what a problem is (e.g., elevated bacteria levels, overwatering, etc.), while magnitude and prevalence address its relative severity (for example, how often or by how much a water quality objective is exceeded).

Social Impacts: Social Impacts are those related to the target audience, society at large, or other specific segments within it.

Spatial Analysis: Spatial analysis allows comparisons between watersheds or other geographic areas. Impacts of runoff and/or control measures can be evaluated based on characteristics of the geographic regions (differences in land use, geology and geomorphology, hydromorphology, etc.). The ability to conduct spatial analysis is generally only limited by the availability of appropriate data for spatial characteristics and project budget.

Source: “Source” means anything with the potential to generate urban runoff or pollutants prior to their introduction to the MS4. A typical program broadly addresses the following source categories: residential areas, construction and development sites, commercial and industrial sources, and municipal operations. Sources may alternatively be defined by the populations associated with areas, facilities, or activities, e.g., residents, dog-walkers, mobile car washers, or restaurant employees.

Source and Impact Component: Source and impact planning and assessment address Outcome Levels 6, 5, and 4. This is the physical component of stormwater management. During planning and assessment, managers consider a variety of parameters to characterize water quality and hydrologic conditions at sources, within MS4s, and in receiving water bodies.

Source Characterization: Source characterization consists of evaluating drainage area and source contributions, defining problem drainage areas and sources, and prioritizing drainage area and source problems. Source characterization studies provide information on the types and concentration of pollutants and flow from a source type (restaurants, metal recycling facilities, etc.) or land use type (low-density residential, light industrial, commercial, etc.).

Source Contribution: Source Contribution can refer either to a source loading or to a reduction in that loading. Source loadings are the flows and pollutant loadings added by sources to a MS4. Source reductions are changes in the amounts of pollutants or reductions in flow associated with specific sources before and after control measures are employed.

Source Control BMP: Source control BMPs help keep pollutants from coming in contract with stormwater. They are extremely varied and their selection will normally be tailored to the specific source type. Examples include good housekeeping practices, pesticide use reduction and picking up after pets.

Source Identification: Source identification provides data on the specific source and/or activity that is contributed to a specific pollutant or flow (over-irrigation, un-covered dumpsters, metal architectural features, etc.)

Source Potential: Source potential describes the likelihood that a given source type will discharge flows or pollutants during wet or dry weather conditions. Since individual sources can’t be observed all the time, managers must often rely on such estimates to gauge their relative importance. See also Threat to Water Quality.

Stormwater Strategic Plan: A Stormwater Strategic Plan (SSP) helps guide the development and modification of a Stormwater Management Plan (SWMP). The purpose of the SSP is to systematically explore and define the strategies that will be considered and incorporated as a part of a SWMP, and to suggest how program managers might choose some options over others. In essence, SSP development is the process by which the strategic approach and content of a SWMP is developed.

Stormwater Management Plan: A Stormwater Management Plan (SWMP) is a detailed management plan to guide the implementation and evaluation of stormwater programs. SWMPs can take on a variety of names and forms, including Urban Runoff Management Plan (URMP) and Drainage Area Management Plan (DAMP). In some cases, a SWMP provides an overarching framework that is both strategic and operational. In others, it is accompanied by additional, more detailed operational plans which describe the programs, activities, policies, or procedures necessary to carry out higher level strategies. There is no standard division of content between strategic and operational plans, so the specific content of each must be determined on a case-by-case basis.

Stormwater Program Component: This component addresses the planning and assessment of stormwater management programs. Managers consider the identified target audiences, critical behaviors, and barriers and bridges to develop stormwater program implementation strategies for bringing about targeted changes. Other activities needed to support general program operation and to obtain feedback for evaluating success are also considered.

Supporting Behaviors: Supporting behaviors include a wide range of potential actions that are distinct from BMP implementation, but that help to form a bridge toward it. Examples include joining a watershed organization, calling a stormwater hotline, conducting employee training, or developing a Stormwater Pollution Prevention Plan (SWPPP). All of these actions are likely to facilitate the implementation of BMPs by target audiences.

Sustainability: Sustainability is the practice of exploring the interconnections among economy, society, and environment to bring about the best solutions for people and the environment now and in the future.

SWRCB: The State Water Resources Control Board (the State Water Board) was created by the California Legislature in 1967. Its mission is to ensure the highest reasonable quality for waters of the State, while allocating those waters to achieve the optimum balance of beneficial uses. The joint authority of water allocation and water quality protection enables the State Water Board to provide comprehensive protection for California's waters. The State Water Board consists of five full-time salaried Members, each filling a different specialty position. Each board member is appointed to a four-year term by the Governor and confirmed by the Senate.

Target Audience: A “target audience” consists of the people (individuals and populations) that are expected to gain knowledge or engage in the behaviors that a stormwater program is intended to elicit. BMPs and other controls are implemented by many types of third parties, so the term “target audience” is broadly defined and virtually any group of people could be a target audience, including fellow municipal staff members, the general public, elected and appointed officials, other government agencies, etc.

Target Audience Actions: Target audience actions are considered in three general categories: pollutant-generating activities (PGAs), best management practices (BMPs), and supporting behaviors. They correspond to Outcome Level 3.

Target Audience Component: The Target Audiences Component is the behavioral portion of the management approach (i.e., the actions of target audiences and the factors that influence them). It encompasses Outcome Levels 3 and 2.

Temporal Change: Temporal change is change over time. A few aspects of temporal change that should be of interest to managers are variability, trends, and changes due to program implementation.

Total Maximum Daily Load (TMDL): TMDLs are numerical calculations of the maximum amount of a pollutant that a water body can assimilate and still meet water quality standards. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point sources (waste load allocations or WLAs) and non-point sources (load allocations or LAs), background contribution, plus a margin of safety.

Treatment Control BMP: TCBMPs are controls that help remove pollutants from stormwater. They can be used in a variety of applications.

Triple Bottom Line: The phrase "the triple bottom line" (or TBL) was first coined in 1994 by John Elkington, the founder of a British consultancy called SustainAbility. He argued that companies should be preparing three separate bottom lines, often referred to as people, planet and profit. . The first is the bottom line of a company's "people account"—a measure in some shape or form of how socially responsible an organization has been throughout its operations. The second is the bottom line of the company's "planet" account—a measure of how environmentally responsible it has been. The third is the traditional measure of corporate profit—the "bottom line" of the profit and loss account. The concept of TBL is now used in a wide variety of disciplines, including environmental and resource management.

True Source Control: True Source Control focuses on the original source of a potential pollutant or on runoff by eliminating or significantly reducing the existence of the potential pollutant or runoff thereby negating the need to physically prevent contact between the two.

USEPA: The United States Environmental Protection Agency (USEPA) has ten Regional offices, each of which is responsible for the execution of the Agency's programs within several states and territories.

Water Quality Control Plan: See Basin Plan

Water Quality Objective WQO: Water Quality Objectives (WQOs) are numerical or narrative limits on constituents or characteristics of water designated to protect designated beneficial uses of the water. [California Water Code Section 13050 (h)]. California's water quality objectives are established by the State and Regional Water Boards in the Water Quality Control Plans. Numeric or narrative limits for pollutants or characteristics of water designed to protect the beneficial uses of the water. In other words, a water quality objective is the maximum concentration of a pollutant that can exist in a receiving water and still generally ensure that the beneficial uses of the receiving water remain protected (i.e., not impaired). Since water quality objectives are designed specifically to protect the beneficial uses, when the objectives are violated the beneficial uses are, by definition, no longer protected and become impaired. This is a fundamental concept under the Porter Cologne Act. Equally fundamental is Porter Cologne's definition of pollution. A condition of pollution exists when the water quality needed to support designated beneficial uses has become unreasonably affected or impaired; in other words, when the water quality objectives have been violated. These underlying definitions (regarding beneficial use protection) are the reason why all waste discharge requirements implementing the federal NPDES regulations require compliance with water quality objectives. (Water quality objectives are also called water quality criteria in the CWA.)

Wet Weather Flow: Wet weather flow refers to the flow in a drainage system from rain events.

This page intentionally left blank

Attachment B

Sources and Activities Profile Sheets

Construction Sources and Activities

Industrial & Commercial Sources and Activities

Municipal Operations Sources and Activities

Planning and Land Development Sources and Activities

This page intentionally left blank

Construction Sources and Activities

This fact sheet has been developed to assist stormwater program managers in understanding why these sources and activities can be problematic in stormwater and urban runoff, what the potential pollutants of concern are, and how effectiveness assessment goals and metrics can be established to assist program managers in answering specific management questions in order to adaptively manage their programs.

The approach and methods described herein provide a "toolbox" for stormwater program managers so that they can select the program assessment methods and metrics that are most meaningful to their overall stormwater program.

INTRODUCTION

The Construction activities can alter natural drainage patterns and affect runoff quality and/or quantity, adding pollutants to the receiving waters.

Excessive erosion and sedimentation are perhaps the most visible water quality impacts due to construction activities. However, there are other, less visible impacts associated with construction sites, such as the potential to discharge other on-site pollutants including cement waste, oil & grease, metals, nutrients, soil additives, pesticides, construction-related chemicals, and other construction waste such as trash. Construction activities can also impact a construction site's runoff sediment supply and transport characteristics. These modifications, which can occur both during and after the construction phase, are a cause of concern and may contribute to adverse impacts in the receiving waters.

The magnitude of the potential impacts from construction sites depends on the construction phase, climatic conditions, and site conditions (i.e., amount of area cleared) as well as the actions taken by the target audience involved at the site. The target audience—the key personnel involved in the activities at these sites—includes contractors, skilled workers, and laborers. Controlling the potential impact(s) of

Each stormwater program may also wish to refer to the following constituent-specific profiles for additional, example program activities, management questions, goals, and metrics that may apply to this program element:

- Bacteria
- Mercury
- ✓ Nutrients
- ✓ Pesticides
- ✓ Sediment
- ✓ Trash

construction site activities requires that the target audience have a basic understanding of the impacts, pollutant sources, and other contributing factors, as well as implementation of the Best Management Practices (BMPs) necessary to eliminate or reduce the discharge of pollutants.

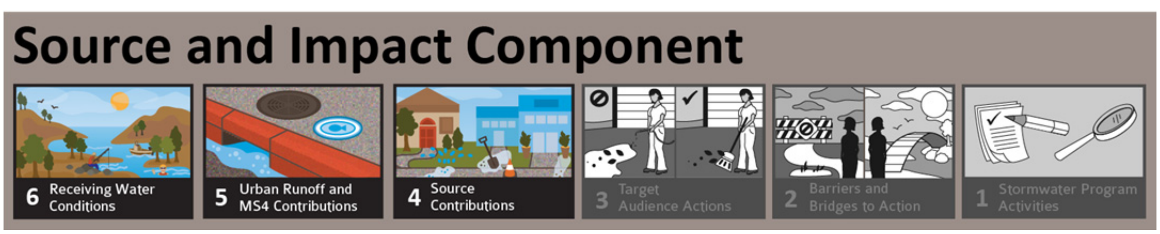
ASSESSMENT OF WATER QUALITY ISSUES AND SOURCES

This section assumes that the following has been determined as a part of the stormwater program planning and assessment process:

- The receiving water quality and/or conditions warrant addressing the constituents associated with these sites, and/or flow as a high priority; AND
- The urban runoff quality and hydrology have been identified as a primary source of the receiving water quality and/or conditions; AND
- These sites have been potentially identified as a major source of the constituents/conditions of concern.

Depending on the stormwater program, the receiving water/urban discharge assessment may be completed by evaluating a local urban discharge/receiving water monitoring program, or it may be completed by assessing other available data and information sources, such as total maximum daily loads (TMDLs), 303(d) lists, special studies, and/or other research and literature.

Note: *The terminology OL6, OL5, etc. used herein refers to the CASQA outcome levels (OL) as defined in Section 2.*



Receiving Water Conditions (OL6) and Urban Runoff and MS4 Contributions (OL5)

The primary constituent of concern at construction sites is excess sediment.

- <u>Sediment</u> - can be detrimental to aquatic life (primary producers, benthic invertebrates, and fish) by interfering with photosynthesis, respiration, growth, reproduction, and oxygen exchange in water bodies. In addition, sediment particles can transport other constituents that are attached to them, including nutrients, trace metals, and hydrocarbons.

In addition to the impacts directly associated with sedimentation, various constituents can also be transported along with sediment particles leaving construction sites. Such constituents may include oil and grease, metals, nutrients, and pesticides. These constituents often originate from on-site activities as well as through organic components, plant residues, and nutrient elements within soils on the construction site, and are thus mobilized by erosion and later deposited downstream during sedimentation.

- Oil & grease - may enter surface water bodies through leaks, spills, automotive cleaning or repair, and waste oil disposal.
- Metals - including lead, zinc, cadmium, copper, chromium, and nickel are commonly found in stormwater. Many of the artificial surfaces of the urban environment (e.g., galvanized metal, paint, automobiles) contain metals, which enter stormwater as the surfaces corrode, flake, dissolve, decay, or leach. Over half the trace metal load carried in stormwater is associated with sediments.
- Nutrients - excess nutrients including nitrogen and phosphorous can lead to excessive vegetation or algal growth which may correspond to aesthetic or aquatic life impairment in surface water.
- Pesticides - used to kill a wide variety of insects, weeds, and other pests can be highly toxic to birds, honeybees, and aquatic life.
- Trash[1] - can cause aesthetic and recreational impacts, inhibit aquatic habitat and vegetation growth, and harm aquatic organisms that ingest or become entangled in the debris. Trash can transport other constituents that are attached to it, including nutrients, bacteria, trace metals, and hydrocarbons.

Source Contributions (OL4)

If, through the planning and assessment process, construction sites are identified as a potential source, then the various activities that occur on-site that may contribute to the discharge of the constituents of concern should be identified and prioritized. Although a stormwater program may address multiple sources concurrently, those sources most likely to be attributed to the constituent(s) of concern should be addressed as high priority.

Although erosion and sedimentation discharges are the most visible and significant sources of constituents associated with construction sites, other constituents such as pH, oil and grease, nutrients, metals, organics, pesticides, and gross constituents may also be considered. The potential sources of the constituents of concern from construction sites are summarized in **Table 1**.

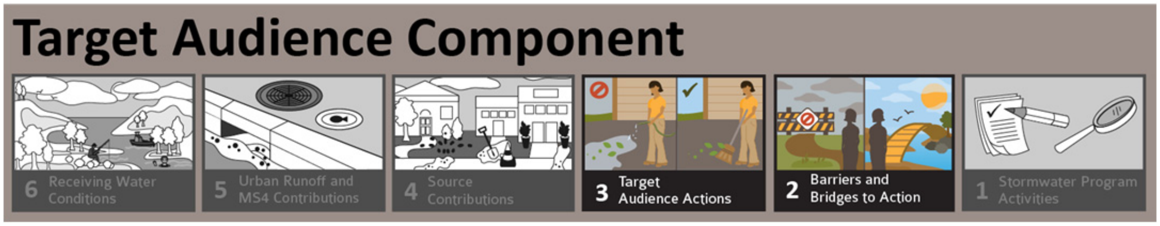
[1] Any debris that does not pass through a 5 mm sieve or preproduction plastic pellets

Construction Sources and Activities

Table 1. Potential Construction Sources of Constituents of Concern

Construction Sources	Constituents of Concern							
	Sediment	pH	Oil, Grease, Fuels	Pesticides	Metals	Other Toxic Chemicals	Trash	Misc. Waste
Construction Practices								
Grading Operations	X						X	
Dewatering Operations	X					X		
Pre-Construction Termiticide Applications				X				
Paving Operations	X	X	X	X		X	X	X
Structure Construction/Painting		X			X	X	X	X
Weed Control				X				
Materials Management								
Material Use and Storage	X	X	X	X	X	X	X	
Waste Management								
Solid Waste	X						X	X
Hazardous Waste						X		
Contaminated Spills	X					X		
Concrete Waste		X					X	X
Sanitary/Septic Waste							X	X
Vehicle/Equipment Management								
Fueling			X			X		X
Maintenance & Washing			X			X		X

Construction Sources and Activities



Target Audience Actions and Barriers and Bridges to Action (OL3, OL2)

The target audiences most involved with construction sites include:

- Contractors;
- Skilled workers; and
- Laborers.

Once the priority sources at the construction sites are identified, the target audience(s) most involved with those sources can also be identified and evaluated to assess their behaviors, as well as the potential barriers to the implementation of the "correct" behaviors. Some of the barriers may include miscommunication between workers, a lack of training, a lack of oversight at the construction site, and/or language barriers. The outreach to the target audiences should be evaluated and prioritized so that the high priority target audiences and sources are addressed using the most effective means of outreach.

Stormwater Program Activities (OL1)

The implementation activities for construction programs typically include the following:

- Reviewing and revising municipal code, as needed;
- Review and revising the plan review and approval process, as needed;
- Developing and updating a construction site inventory;
- Providing outreach to construction site owners/operators;
- Providing training to key staff who are involved in the construction program;

- Conducting site inspections and follow up inspections to verify BMP implementation; and
- Pursuing progressive enforcement actions for those sites that do not comply with the stormwater requirements.

For the purposes of program effectiveness assessment, the OL1 activities simply demonstrate that the program is being implemented pursuant to the municipal stormwater permit. The assessment at this outcome level does not indicate the effect that the program is having (i.e., are the objectives/goals of the program being met?). For that reason, the goals and metrics identified for the program will primarily focus on OL2-OL6.

MANAGEMENT QUESTIONS, GOAL SETTING, AND METRIC IDENTIFICATION

A large portion of the construction program is typically focused on site inspections which can serve as the basis for establishing baselines regarding how the sites are operating, what constituents are of concern, and the level of BMP implementation and maintenance that is required in order to address the constituents. In turn, follow-up inspections can be used to track changes and ensure that the sites are properly implementing and maintaining their BMPs. For programs that have existing data, these data can be used to determine the appropriate baseline factors by which future reductions can be measured. Some potential goals for existing programs may include:

- An increase in BMPs that are effective at removing constituents of concern (e.g., TMDLs), and are suitable to site constraints; and/or
- A reduction in the number of violations.

Another important aspect of this program element is educating the target audiences at the construction sites—the construction site owners/operators and their sub-contractors. Survey results may serve as a way to establish baseline information on current knowledge and practices. Some example goals, targets (where applicable) and projected timeframes are identified below. The targets and goals/metrics in **Table 2** below are examples. Each stormwater program will need to decide what numbers are most applicable to their program.

Example Management Questions and Goals

The following questions may also be used to assist in identifying/ establishing goals:

Outcome Level	Management Question
1	Is the program element/control measure/activity being implemented in accordance with the Permit Provisions, SWMP control measures and performance standards?
2	Does the program element/control measure/activity raise the target audience's awareness of an issue?
3	Does the program element/control measure/activity change a target audience's behavior which will result in the proper design and implementation of recommended BMPs?
4	Does the program element/control measure/activity reduce the load of constituents from the sources to the storm drain system?

Construction Sources and Activities

Table 2. Example Management Questions, Goals, and Metrics

Program Activity	Management Question	Goal/Metric[2]	Data/Information to be Collected
Outcome Level 4			
Inspections	Are BMPs in place to prevent debris from leaving site?	• 90% -100% of debris is captured and not released to the environment.	Track quantities diverted to trash, other disposal streams Track BMPs in place to prevent materials (e.g., sediment, trash, scrap metal) from leaving site and whether they are properly maintained.
Outcome Level 3			
Inspections	Did inspections change behavior?	• Increase percent of people responding to surveys that they are implementing BMPs to 90% • Increase sites in compliance upon inspection to 75% within 2 years • Increase sites in compliance upon inspection to 90% within 5 years • Enforcement actions are required at <10% of the sites and of those, <5% are repeat offenders	Track BMP implementation survey results. Track initial site inspection results. Track all sites and number and types of enforcement actions issued.
Inspections	Are key staff at the construction sites maintaining the BMPs?	• Based on the site inspections, > 90% of the sites have BMPs that are maintained correctly. • Enforcement actions are required at <10% of the sites and of those, <5% are repeat offenders	Track all site inspection results. Track all sites and number and types of enforcement actions issued.

[2] It should be recognized that goals and metrics may be limited to TMDL requirements.

Construction Sources and Activities

Program Activity	Management Question	Goal/Metric[2]	Data/Information to be Collected
Outcome Level 2			
Training	Was training effective for construction staff?	• For each training module, increase number of attendees ranking the training as effective to 95% within 5 years • For each training module, increase post-training survey percent of answers correct to 95% within 5 years	Track training evaluation results. Track pre- and post-training survey results.

This page intentionally left blank

Industrial & Commercial Sources and Activities

This fact sheet has been developed to assist stormwater program managers in understanding why these sources and activities can be problematic in stormwater and urban runoff, what the potential pollutants of concern are, and how effectiveness assessment goals and metrics can be established to assist program managers in answering specific management questions in order to adaptively manage their programs.

The approach and methods described herein provide a "toolbox" for stormwater program managers so that they can select the program assessment methods and metrics that are most meaningful to their overall stormwater program.

INTRODUCTION

The Construction activities can alter natural drainage patterns and affect runoff quality and/or quantity, adding pollutants to the receiving waters.

Activities conducted at industrial and commercial facilities can adversely affect runoff quality, adding pollutants to the receiving waters. Water quality impacts from industrial and commercial facilities can include runoff associated with vehicle and equipment maintenance and cleaning, trash and debris in outdoor areas, and runoff associated with landscape maintenance.

The magnitude of the potential impacts from industrial and commercial facilities depends on the type of business or facility, climatic conditions, and site conditions as well as the actions taken by the target audience involved at the facility. The target audience—the key personnel involved in the activities at these sites—includes the owners and operators, as well as the skilled workers, and laborers. Controlling the potential impact(s) of industrial/commercial facilities requires a basic understanding of the activities that are conducted on site, the potential pollutant sources, and the Best Management Practices (BMPs) necessary to

Each stormwater program may also wish to refer to the following constituent-specific profiles for additional, example program activities, management questions, goals, and metrics that may apply to this program element:

- ✓ Bacteria
- ✓ Mercury
- ✓ Nutrients
- ✓ Pesticides
- ✓ Sediment
- ✓ Trash

eliminate or reduce the discharge of pollutants.

The approach and methods described herein provide a "toolbox" for stormwater program managers so that they can select the methods and metrics that are most meaningful to their overall stormwater program.

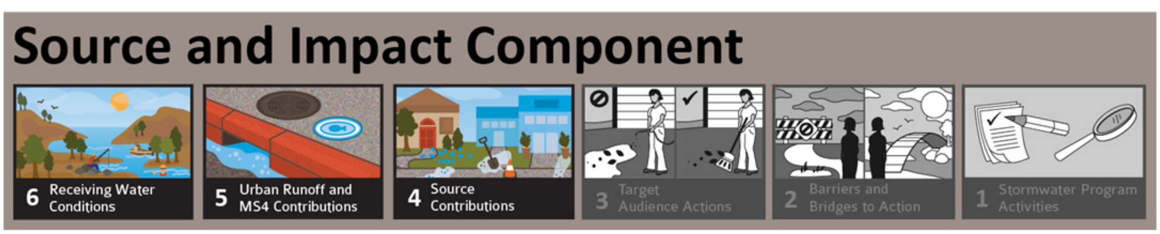
ASSESSMENT OF WATER QUALITY ISSUES AND SOURCES

This section assumes that the following has been determined as a part of the stormwater program planning and assessment process:

- The receiving water quality and/or conditions warrant addressing the constituents associated with these sites, and/or flow as a high priority; AND
- The urban runoff quality and hydrology have been identified as a primary source of the receiving water quality and/or conditions; AND
- These sites have been potentially identified as a major source of the constituents/conditions of concern.

Depending on the stormwater program, the receiving water/urban discharge assessment may be completed by evaluating a local urban discharge/receiving water monitoring program, or it may be completed by assessing other available data and information sources, such as total maximum daily loads (TMDLs), 303(d) lists, special studies, and/or other research and literature.

Note: *The terminology OL6, OL5, etc. used herein refers to the CASQA outcome levels (OL) as defined in Section 2.*



Receiving Water Conditions (OL6) and Urban Runoff and MS4 Contributions (OL5)

The primary constituents of concern at industrial and commercial sites will vary depending on the type of business and facility and the extent and type of activities conducted outside. Constituents of concern may include metals, mercury, organics and toxicants, oil and grease, and pesticides.

Industrial & Commercial Sources and Activities

- Metals - including lead, zinc, cadmium, copper, chromium, and nickel are commonly found in stormwater. Many of the artificial surfaces of the urban environment (e.g., galvanized metal, paint, automobiles) contain metals, which enter stormwater as the surfaces corrode, flake, dissolve, decay, or leach. Over half the trace metal load carried in stormwater is associated with sediments.

- Mercury - has useful properties which have been applied in many products and chemical applications historically, and it is still widely used. Improper disposal of these products or mercury compounds can contribute mercury directly to wastewater, stormwater, and the atmosphere.

- Organics and toxicants - are widely used as cleaners, solvents, or sealers and may be improperly stored, disposed of, or dumped into storm drains and inlets.

- Oil & grease - may enter surface water bodies through leaks, spills, automotive cleaning or repair, and waste oil disposal.

- Pesticides - used to kill a wide variety of insects, weeds, and other pests can be highly toxic to birds, honeybees, and aquatic life.

Other constituents of concern that may originate from industrial and commercial sites include nutrients, sediment and trash.

- Nutrients - excess nutrients including nitrogen and phosphorous can lead to excessive vegetation or algal growth which may correspond to aesthetic or aquatic life impairment in surface water.

- Sediment - can be detrimental to aquatic life (primary producers, benthic invertebrates, and fish) by interfering with photosynthesis, respiration, growth, reproduction, and oxygen exchange in water bodies. In addition, sediment particles can transport other constituents that are attached to them including nutrients, bacteria, trace metals, and hydrocarbons.

- Trash[1] - can cause aesthetic and recreational impacts, inhibit aquatic habitat and vegetation growth, and harm aquatic organisms that ingest or become entangled in the debris. Trash can transport other constituents that are attached to it, including nutrients, bacteria, trace metals, and hydrocarbons.

[1] Any debris that does not pass through a 5 mm sieve or preproduction plastic pellets

Industrial & Commercial Sources and Activities

Source Contributions (OL4)

The potential sources of constituents from industrial and commercial sites include the following categories of activities (see also **Table 1**):

- Vehicle and Equipment Fueling: Spills and leaks that occur during vehicle and equipment fueling can contribute hydrocarbons, oil and grease, as well as heavy metals to stormwater runoff.

- Vehicle and Equipment Washing and Steam Cleaning: Washwater, if not properly contained, can runoff the site to the storm drain carrying sediment, and constituents on site (metals, trash, nutrients, etc.) to the storm drain or receiving water.

- Vehicle and Equipment Maintenance and Repair: Engine repair and service (e.g. parts cleaning), replacement of fluids (e.g. oil change), and outdoor equipment storage and parking (dripping engines) can impact water quality if stormwater runoff from areas with these activities occurring on them becomes polluted by a variety of contaminants.

- Outdoor Loading and Unloading of Materials: The loading/unloading of materials usually takes place outside on docks or terminals; therefore, materials spilled, leaked, or lost during loading/unloading may collect in the soil or on other surfaces and have the potential to be carried away by stormwater runoff or when the area is cleaned.

- Outdoor Container Storage of Liquids: Accidental releases of materials from above ground liquid storage tanks, drums, and dumpsters present the potential for contaminating stormwater with many different constituents. Tanks may store many potential stormwater runoff constituents, such as gasoline, aviation gas, diesel fuel, ammonia, solvents, syrups, etc.

- Outdoor Process Equipment: Outside process equipment operations and maintenance can contaminate stormwater runoff. Activities, such as grinding, painting, coating, sanding, degreasing or parts cleaning, landfills and waste piles, solid waste treatment and disposal, are examples of process operations that can lead to contamination of stormwater runoff.

- Outdoor Storage of Raw Materials: Raw materials, by-products, finished products, containers, and material storage areas exposed to rain and/or runoff can pollute stormwater. Improper storage of these materials can result in accidental spills and the release of materials.

- Waste Handling and Disposal: Improper storage and handling of solid wastes can allow toxic compounds, oils and greases, heavy metals, nutrients, suspended solids, and other constituents to enter stormwater runoff.

Industrial & Commercial Sources and Activities

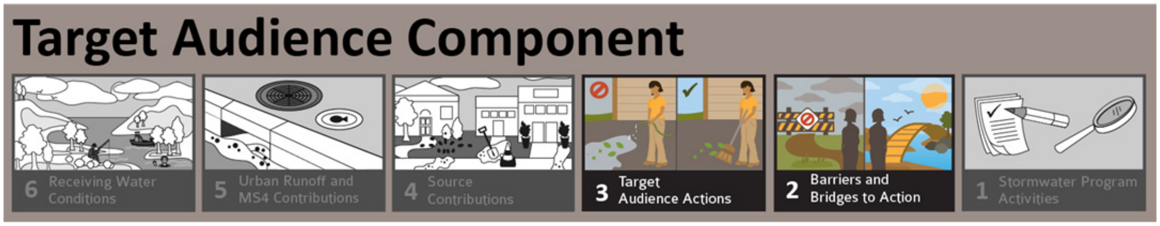
- Building and Grounds Maintenance and Repair: Activities may include landscaping, building repair, and graffiti removal. Landscaping can disturb soil and create a source of sediment. In addition, fertilizers, which are a source of nutrients, and pesticides may be used. If disturbed soil is not stabilized or the area is over irrigated these constituents can reach the storm drain or receiving waters

- Parking/Storage Area Maintenance: These areas consist of a high percentage of impervious cover and automobile exposure contributes to constituents of concern such as oil and grease, trash, and metals.

Table 1. Potential Industrial & Commercial Sources of Constituents of Concern

Activity or Facility Type	Constituents of Concern								
	Metals	Mercury	Organics and Toxicants	Oil & Grease	Nutrients	Sediment	Trash	Bacteria	Pesticides
Vehicle & Equipment Fueling	X		X	X					
Vehicle & Equipment Washing and Steam Cleaning	X		X	X	X	X			
Vehicle & Equipment Maintenance and Repair	X	X	X	X					
Outdoor Loading and Unloading of Materials	X		X	X	X	X	X		
Outdoor Container Storage of Liquids	X		X	X	X				X
Outdoor Process Equipment Operations and Maintenance	X		X	X		X			
Outdoor Storage of Raw Materials, Products and Byproducts	X		X	X	X	X	X		
Waste Handling and Disposal	X	X	X	X			X	X	
Building and Grounds Maintenance	X				X	X	X	X	X
Parking/Storage Area Maintenance	X		X	X			X	X	

Industrial & Commercial Sources and Activities



Target Audience Actions and Barriers and Bridges to Action (OL3, OL2)

The target audiences most involved with industrial/commercial sites include:

- Facility owners/operators; and
- Municipal inspectors.

Once the priority sources at industrial/commercial sites are identified, the target audience(s) most involved with those sources can also be identified and evaluated to assess their behaviors, as well as the potential barriers to the implementation of the "correct" behaviors. Some of the barriers may include miscommunication between workers, a lack of training, a lack of oversight at a facility, and/or language barriers. The outreach to the target audiences should be evaluated and prioritized so that the high priority target audiences and sources are addressed using the most effective means of outreach.

MANAGEMENT QUESTIONS, GOAL SETTING, AND METRIC IDENTIFICATION

A large portion of the industrial/commercial program is typically focused on identifying activities of concern and associated BMPs that address potential sources of constituents to the storm drain system. Training and inspections can be used to track changes and ensure that the sites are properly implementing and maintaining their BMPs. For programs that have existing data, these data can be used to determine the appropriate baseline factors by which future reductions can be measured. Some potential goals for existing programs may include:

- An increase in BMP implementation and maintenance at industrial/commercial sites;
- A reduction in the number of violations; and/or
- A reduction in constituent concentrations in stormwater runoff.

Another important aspect of this program element is educating the target audiences associated with industrial/commercial requirements –the facility owners and operators and municipal inspectors. Survey results may serve as a way to establish baseline information on current knowledge and practices.

Some example goals, targets (where applicable) and projected timeframes are identified below. The targets and goals in **Table 2** are examples. Each stormwater program will need to decide what numbers are most applicable to their program.

Example Management Questions and Goals

The following questions may also be used to assist in identifying/ establishing goals:

Outcome Level	Management Question
1	Is the program element/control measure/activity being implemented in accordance with the Permit Provisions, SWMP control measures and performance standards?
2	Does the program element/control measure/activity raise the target audience's awareness of an issue?
3	Does the program element/control measure/activity change a target audience's behavior which will result in the proper design and implementation of recommended BMPs?
4	Does the program element/control measure/activity reduce the load of constituents from the sources to the storm drain system?

Table 2. Example Management Questions, Goals, and Metrics

Program Activity	Management Question	Goal/Metric[2]	Data/Information to be Collected
Outcome Level 4			
Inspections	Was the amount of trash from commercial/industrial areas to the storm drain reduced?	• Reduce amount from major commercial/industrial areas by 50% in 5-10 years.	Track amount of trash removed from trash capture devices that receive runoff from commercial/industrial areas.
Outcome Level 3			
Inspections	Did inspections change behavior?	• Increase percent of staff responding to surveys that they are implementing BMPs to 90% • Increase sites in compliance upon inspection to 75% within 2 years • Increase sites in compliance upon inspection to 90% within 5 years	Track BMP implementation survey results. Track initial site inspection results.
Inspections	Did enforcement actions change behavior?	• Reduce percent of sites receiving enforcement actions by 10% each year • Reduce number of notice of violations by 10% each year • For each training module, increase post-training survey % of answers correct to 95% within 5 years	Track all sites and number and types of enforcement actions issued. Track pre- and post-training survey results.

[2] It should be recognized that goals and metrics may be limited to TMDL requirements.

Program Activity	Management Question	Goal/Metric[2]	Data/Information to be Collected
Outcome Level 2			
Inspections	Did inspections increase awareness?	• Increase number of sites incorporating minimum required BMPs to 75% in 2 years and 90% in 5 years	Track initial and follow-up site inspection results.
Training	Was inspector training effective?	• For each training module, increase number of attendees ranking the training as effective to 95% within 5 years • For each training module, increase post-training survey percent of answers correct to 95% within 5 years	Track training evaluation results. Track pre- and post-training survey results.

Municipal Operations Sources and Activities

This fact sheet has been developed to assist stormwater program managers in understanding why these sources and activities can be problematic in stormwater and urban runoff, what the potential pollutants of concern are, and how effectiveness assessment goals and metrics can be established to assist program managers in answering specific management questions in order to adaptively manage their programs.

The approach and methods described herein provide a “toolbox” for stormwater program managers so that they can select the program assessment methods and metrics that are most meaningful to their overall stormwater program.

INTRODUCTION

Municipal operations can adversely affect runoff quality, adding pollutants to the receiving waters. Water quality impacts from municipal operations can include runoff associated with vehicle and equipment maintenance and cleaning, trash and debris in outdoor areas, and runoff associated with landscape maintenance.

The magnitude of the potential impacts from municipal operations depends on the type of activities that are being conducted, climatic conditions, and site conditions, as well as the actions taken by the target audience involved at the site. The target audience—the key personnel involved in the activities at these sites—includes contractors as well as the municipal staff. Controlling the potential impact(s) of municipal operations requires a basic understanding of the activities that are conducted on site as well as in the field, the potential pollutant sources and the Best Management Practices (BMPs) necessary to eliminate or reduce the discharge of pollutants.

Each stormwater program may also wish to refer to the following constituent-specific profiles for additional, example program activities, management questions, goals, and metrics that may apply to this program element:

- ✓ Bacteria
- Mercury
- ✓ Nutrients
- ✓ Pesticides
- ✓ Sediment
- ✓ Trash

Municipal Operations Sources and Activities

ASSESSMENT OF WATER QUALITY ISSUES AND SOURCES

This section assumes that the following has been determined as a part of the stormwater program planning and assessment process:

- The receiving water quality and/or conditions warrant addressing the constituents associated with these sites, and/or flow as a high priority; AND
- The urban runoff quality and hydrology have been identified as a primary source of the receiving water quality and/or conditions; AND
- These sites have been potentially identified as a major source of the constituents/conditions of concern.

Depending on the stormwater program, the receiving water/urban discharge assessment may be completed by evaluating a local urban discharge/receiving water monitoring program, or it may be completed by assessing other available data and information sources, such as total maximum daily loads (TMDLs), 303(d) lists, special studies, and/or other research and literature.

Note: *The terminology OL6, OL5, etc. used herein refers to the CASQA outcome levels (OL) as defined in Section 2.*

Receiving Water Conditions (OL6) and Urban Runoff and MS4 Contributions (OL5)

The constituents of concern associated with municipal operations will vary depending on the land use and activities occurring onsite. Constituents of concern can include trash, metals, nutrients, pesticides, sediment, oil & grease, and organics and toxicants.

- <u>Trash</u>[1] - can cause aesthetic and recreational impacts, inhibit aquatic habitat and vegetation growth, and harm aquatic organisms that ingest or become entangled in the debris. Trash can transport other constituents that are attached to it, including nutrients, bacteria, trace metals, and hydrocarbons.

1 Any debris that does not pass through a 5 mm sieve or preproduction plastic pellets

- Metals - including lead, zinc, cadmium, copper, chromium, and nickel are commonly found in stormwater. Many of the artificial surfaces of the urban environment (e.g., galvanized metal, paint, automobiles) contain metals, which enter stormwater as the surfaces corrode, flake, dissolve, decay, or leach. Over half the trace metal load carried in stormwater is associated with sediments.

- Nutrients - excess nutrients including nitrogen and phosphorous can lead to excessive vegetation or algal growth which may correspond to aesthetic or aquatic life impairment in surface water.

- Pesticides - used to kill a wide variety of insects, weeds, and other pests can be highly toxic to birds, honeybees, and aquatic life.

- Sediment - can be detrimental to aquatic life (primary producers, benthic invertebrates, and fish) by interfering with photosynthesis, respiration, growth, reproduction, and oxygen exchange in water bodies. In addition, sediment particles can transport other constituents that are attached to them including nutrients, trace metals, and hydrocarbons.

- Oil & grease - may enter surface water bodies through leaks, spills, automotive cleaning or repair, and waste oil disposal.

- Organics and toxicants - are widely used as cleaners, solvents, or sealers and may be improperly stored, disposed of, or dumped into storm drains and inlets.

Source Contributions (OL4)

If, through the planning and assessment process, municipal operations and/or sites are identified as a potential source, then the various activities that occur on site that may contribute to the discharge of the constituents of concern should be identified and prioritized. Although a stormwater program may address multiple sources concurrently, those sources most likely to be attributed to the constituent(s) of concern should be addressed as high priority.

The potential sources of constituents from municipal operations include the following categories of activities:

- Building and Grounds Maintenance and Repair: Activities may include landscaping, building repair, and graffiti removal.

- Parking/Storage Area Maintenance: These areas consist of a high percentage of impervious cover and automobile exposure contributes to constituents of concern such as oil and grease, trash, and metals.

Municipal Operations Sources and Activities

- Waste Handling and Disposal: Improper storage and handling of solid wastes can allow toxic compounds, oils and greases, heavy metals, nutrients, pathogens, suspended solids, and other constituents to enter stormwater runoff.

- Vehicle and Equipment Fueling: Spills and leaks that occur during vehicle and equipment fueling can contribute hydrocarbons, oil and grease, as well as heavy metals to stormwater runoff.

- Vehicle and Equipment Maintenance and Repair: Engine repair and service (e.g. parts cleaning), replacement of fluids (e.g. oil change), and outdoor equipment storage and parking (dripping engines) can impact water quality if stormwater runoff from areas with these activities occurring on them becomes polluted by a variety of contaminants.

- Vehicle and Equipment Washing and Steam Cleaning: Wash water, if not properly contained, can runoff the site to the storm drain carrying sediment, and constituents on site (metals, trash, nutrients, etc.) to the storm drain or receiving water.

- Outdoor Loading and Unloading of Materials: The loading/unloading of materials usually takes place outside on docks or terminals; therefore, materials spilled, leaked, or lost during loading/unloading may collect in the soil or on other surfaces and have the potential to be carried away by stormwater runoff or when the area is cleaned.

- Outdoor Container Storage of Liquids: Accidental releases of materials from above ground liquid storage tanks, drums, and dumpsters present the potential for contaminating stormwater with many different constituents. Tanks may store many potential stormwater runoff constituents, such as gasoline, aviation gas, diesel fuel, ammonia, solvents, syrups, etc.

- Outdoor Storage of Raw Materials: Raw materials, by-products, finished products, containers, and material storage areas exposed to rain and/or runoff can pollute stormwater. Improper storage of these materials can result in accidental spills and the release of materials.

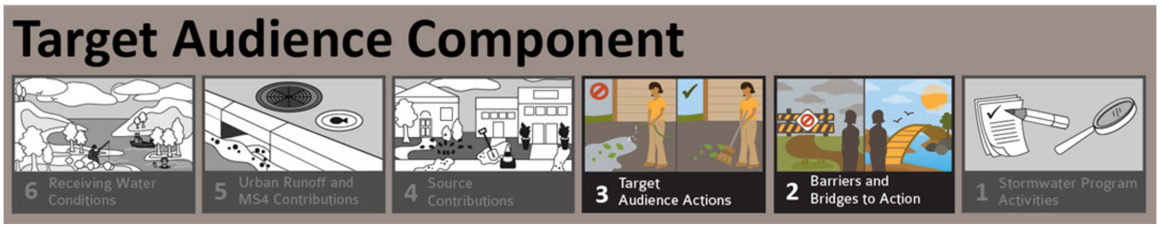
- Outdoor Process Equipment: Outside process equipment operations and maintenance can contaminate stormwater runoff. Activities, such as grinding, painting, coating, sanding, degreasing or parts cleaning, landfills and waste piles, solid waste treatment and disposal, are examples of process operations that can lead to contamination of stormwater runoff.

- Over-Water Activities: Over-water activities occur at boat and ship repair yards, marinas, and yacht clubs.

Municipal Operations Sources and Activities

- Landscape Maintenance: Landscaping can disturb soil and create a source of sediment. In addition, fertilizers, which are a source of nutrients, and pesticides may be used. If disturbed soil is not stabilized or the area is over-irrigated, these constituents can reach the storm drain or receiving waters

- Sanitary Sewer Overflows: Sanitary Sewer Overflows (SSOs) may reach the storm drain and are a source of pathogens and bacteria.



Target Audience Actions and Barriers and Bridges to Action (OL3, OL2)

The target audiences most involved with municipal operations include:

- Maintenance crews;
- Roads crews;
- Park and recreation crews;
- Street sweepers;
- Waste pickup; and
- Contract/lease staff.

Once the priority sources at the municipal operations are identified, the target audience(s) most involved with those sources can also be identified and evaluated to assess their behaviors, as well as the potential barriers to the implementation of the "correct" behaviors. Some of the barriers may include miscommunication between workers, a lack of training, a lack of oversight at a facility, and/or language barriers. The outreach to the target audiences should be evaluated and prioritized so that the high priority target audiences and sources are addressed using the most effective means of outreach.

MANAGEMENT QUESTIONS, GOAL SETTING, AND METRIC IDENTIFICATION

A large portion of the municipal operations program is typically focused on identifying activities of concern and associated BMPs that address potential sources of constituents to the storm drain system. Training and inspections can be used to track changes and ensure that the sites are properly implementing and maintaining their BMPs. It is important that the Permittees develop management questions (both environmental and programmatic), as well as measureable, achievable goals that are consistent with the program's priorities. Some potential goals for existing programs may include:

- An increase in BMP implementation and maintenance at municipal facilities;
- A reduction in constituent concentrations in stormwater runoff;
- Increase knowledge/understanding of program impacts by target audiences (i.e., the maintenance, roads and parks and recreation crews, street sweepers, and waste pickup staff).

Some example goals, targets (where applicable) and projected timeframes are identified below. The targets and goals in **Table 1** are examples. Each stormwater program will need to decide what numbers are most applicable to their program.

Example Management Questions and Goals

The following questions may also be used to assist in identifying/ establishing goals:

Outcome Level	Management Question
1	Is the program element/control measure/activity being implemented in accordance with the Permit Provisions, SWMP control measures and performance standards?
2	Does the program element/control measure/activity raise the target audience's awareness of an issue?
3	Does the program element/control measure/activity change a target audience's behavior which will result in the proper design and implementation of recommended BMPs?
4	Does the program element/control measure/activity reduce the load of constituents from the sources to the storm drain system?

Municipal Operations Sources and Activities

Table 1. Example Management Questions, Goals, and Metrics

Program Activity	Management Question	Goal/Metric[2]	Data/Information to be Collected
Outcome Level 4			
Street Sweeping	Did street sweeping remove sediment and other debris?	• Street sweeping conducted for 90% of streets on a *[insert stormwater program's schedule—e.g., weekly, monthly]* basis.	Track amount of debris and sediment collected via street sweeping.
Outcome Level 3			
Inspections	Did inspections change behavior?	• Increase percent of catch basins with screens or covers to 90% • Increase use of secondary containment and/or trash booms for outdoor areas to 90-100% • Reduce improper lateral connections by 50%	Track number of catch basins with screens/covers. Track implementation of secondary containment/trash booms at municipal sites. Track number of improper lateral connections observed/ eliminated during inspections.
Inspections	Did enforcement actions change behavior?	• Reduce percent of sites receiving enforcement actions by 10% each year • Reduce number of notice of violations by 10% each year • For each training module, increase post-training survey % of answers correct to 95% within 5 years	Track all sites and number and types of enforcement actions issued. Track pre- and post-training survey results.

[2] It should be recognized that goals and metrics may be limited to TMDL requirements.

Municipal Operations Sources and Activities

Program Activity	Management Question	Goal/Metric[2]	Data/Information to be Collected
Outcome Level 2			
Training	Did street sweeper operators modify operation of street sweepers?	• Increase number of staff with knowledge of guidelines for street sweeping operations that improve water quality to 95% within 2 years	Track pre- and post-training survey results.
Training	Was training effective for street sweeper operators?	• For each training module, increase number of attendees ranking the training as effective to 95% within 5 years • For each training module, increase post-training survey percent of answers correct to 95% within 5 years	Track training evaluation results. Track pre- and post-training survey results.

Planning and Land Development Sources and Activities

This fact sheet has been developed to assist stormwater program managers in understanding why these sources and activities can be problematic in stormwater and urban runoff, what the potential pollutants of concern are, and how effectiveness assessment goals and metrics can be established to assist program managers in answering specific management questions in order to adaptively manage their programs.

The approach and methods described herein provide a “toolbox” for stormwater program managers so that they can select the program assessment methods and metrics that are most meaningful to their overall stormwater program.

INTRODUCTION

Land development can alter natural drainage patterns and affect runoff quality and/or quantity, adding pollutants to the receiving waters. Water quality impacts from new or re-development can include the generation of dry-weather runoff, increases in the rates and volume of stormwater runoff that may increase the downstream erosion potential, and increased discharges of pollutants in wet weather (stormwater) runoff.

The magnitude of the potential impacts depends on the site conditions, layout and design of the site, and climatic conditions.

The target audience—the key personnel involved in the activities at these sites—includes the planners, engineers, developers, as well as BMP owners and building and construction inspectors. Controlling the potential impact(s) of land development requires a basic understanding of the activities that are conducted as a part of the planning process as well as on-site, the potential pollutant sources, and the Best Management Practices (BMPs) necessary to eliminate or reduce the discharge of pollutants.

Planning and Land Development Sources and Activities

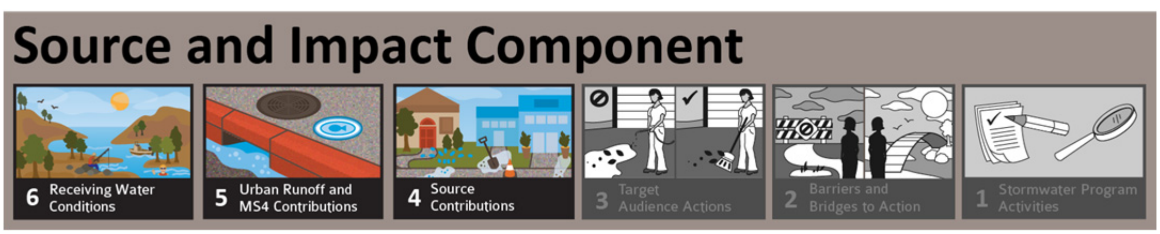
ASSESSMENT OF WATER QUALITY ISSUES AND SOURCES

This section assumes that the following has been determined as a part of the stormwater program planning and assessment process:

- The receiving water quality and/or conditions warrant addressing the constituents associated with these sites, and/or flow as a high priority; AND
- The urban runoff quality and hydrology have been identified as a primary source of the receiving water quality and/or conditions; AND
- These sites have been potentially identified as a major source of the constituents/conditions of concern.

Depending on the stormwater program, the receiving water/urban discharge assessment may be completed by evaluating a local urban discharge/receiving water monitoring program, or it may be completed by assessing other available data and information sources, such as total maximum daily loads (TMDLs), 303(d) lists, special studies, and/or other research and literature.

Note: *The terminology OL6, OL5, etc. used herein refers to the CASQA outcome levels (OL) as defined in Section 2.*



Receiving Water Conditions (OL6) and Urban Runoff and MS4 Contributions (OL5)

The constituents of concern associated with land development will vary depending on the land use and activities occurring onsite. Constituents of concern can include flow, sediment, nutrients, pathogens, oil and grease, metals, organics, pesticides, and trash.

- Flow - new development typically results in more runoff volume and higher rate of runoff (flow). Problems include washing out in-stream habitat, eroding streambeds and banks, and changing downstream ecosystems.
- Sediment - can be detrimental to aquatic life (primary producers, benthic invertebrates, and fish) by interfering with photosynthesis, respiration, growth, reproduction, and oxygen exchange in water bodies. In addition, sediment particles can transport other

constituents that are attached to them, including nutrients, trace metals, and hydrocarbons.

- Nutrients - excess nutrients, including nitrogen and phosphorous, can lead to excessive vegetation or algal growth, which may correspond to aesthetic or aquatic life impairment in surface water.

- Pathogens (bacteria and viruses) - are common contaminants of stormwater. Sources of these contaminants include animal excrement (e.g., pet waste) and sanitary sewer overflows.

- Oil & grease - may enter surface water bodies through leaks, spills, automotive cleaning or repair, and waste oil disposal.

- Metals - including lead, zinc, cadmium, copper, chromium, and nickel are commonly found in stormwater. Many of the artificial surfaces of the urban environment (e.g., galvanized metal, paint, automobiles) contain metals, which enter stormwater as the surfaces corrode, flake, dissolve, decay, or leach. Over half the trace metal load carried in stormwater is associated with sediments.

- Organics and toxicants - are widely used as cleaners, solvents, or sealers and may be improperly stored, disposed of, or dumped into storm drains and inlets.

- Pesticides - used to kill a wide variety of insects, weeds, and other pests can be highly toxic to birds, honeybees, and aquatic life.

- Trash[1] - can cause aesthetic and recreational impacts, inhibit aquatic habitat and vegetation growth, and harm aquatic organisms that ingest or become entangled in the debris. Trash can transport other constituents that are attached to it, including nutrients, bacteria, trace metals, and hydrocarbons.

Source Contributions (OL4)

If, through the planning and assessment process, new development and redevelopment sites are identified as a potential source, then the various activities that occur on-site that may contribute to the discharge of the constituents of concern should be identified and prioritized. Although a stormwater program may address multiple sources concurrently, those sources most likely to be attributed to the constituent(s) of concern should be addressed as high priority.

[1] Any debris that does not pass through a 5 mm sieve or preproduction plastic pellets

Planning and Land Development Sources and Activities

The potential sources of the constituents of concern from new development and redevelopment sites are outlined below. The constituents of concern for each site are activity and land use dependent.

- Residential: Residential development results in the creation of impervious cover, landscaped areas, and lawns which increases runoff volume and flow. Additionally, rainfall washes sediment and constituents off impervious surfaces and into nearby storm drains. Landscaping can disturb soil and create a source of sediment. In addition, fertilizers (which are a source of nutrients) and pesticides may be washed into storm drains when inappropriately applied or over applied.

- Commercial: Commercial areas tend to have a high percentage of impervious cover and, therefore, can increase stormwater runoff flow and volume. Commercial areas usually incorporate some landscaping which may result in fertilizers and pesticides in stormwater runoff.

- Industrial: Development of industrial areas can result in the creation of parcels with a high percentage of impervious cover. The constituents of concern associated with industrial development are dependent on the types of activities occurring on-site but are likely to include oil and grease and trash.

- Retail Gasoline Outlets: A high percentage of impervious cover combined with automotive exposure and the potential for gas spills results in the potential contribution of oil and grease and trash.

- Automotive Repair Shops: Automotive repair shop activities usually include storage of inoperable vehicles, changing fluids, and replacing auto parts. These activities can directly or indirectly contribute to oil and grease, metals, organics and trash in stormwater runoff.

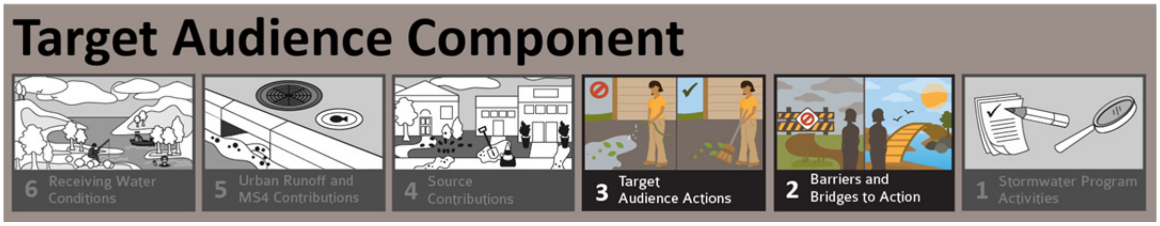
- Restaurants: Waste or wash water generated by restaurants often contain materials such as food wastes, oil and grease, and cleaning agents. Restaurants may also have some landscaping located onsite which can contribute to pesticides and fertilizers in stormwater runoff.

- Parking Lots: Parking lots largely consist of impervious surface with some landscaping. Cars and other motor vehicles in parking lots can contribute to oil and grease, metals and other constituents of concern that wash off pavement and into storm drains. Parking lots usually incorporate some landscaping which may result in fertilizers and pesticides in stormwater runoff.

- Streets, Highways, and Freeways: Similar to parking lots, streets, highways and freeways largely consist of impervious surfaces with the landscaping included in the right-of-way. Cars and other motor vehicles contribute to oil and grease, metals, and other constituents of concern that wash off pavement and into storm drains.

Planning and Land Development Sources and Activities

For Planning and Land Development, pollutants will be linked to the ultimate land use.



Target Audience Actions and Barriers and Bridges to Action (OL3, OL2)

The target audiences most involved with new development and redevelopment sites include:

- Plan checkers;
- Engineers;
- Developers;
- BMP owners/responsible parties; and
- Building and construction inspectors.

Once the priority sources at the new development and redevelopment sites are identified, the target audience(s) most involved with those sources can be identified and evaluated to assess their behaviors, as well as the potential barriers to the implementation of the "correct" behaviors. Some of the barriers may include lack of consistency between plan checkers, miscommunication between workers, lack of training, lack of oversight at the new development and redevelopment site, and/or language barriers. The outreach to the target audiences should be evaluated and prioritized so that the high priority target audiences and sources are addressed using the most effective means of outreach.

MANAGEMENT QUESTIONS, GOAL SETTING, AND METRIC IDENTIFICATION

A large portion of the land development program is typically focused on implementation of land development requirements which can serve as the basis for establishing baselines regarding the level of BMP implementation required in order to address the constituents of concern. In turn, follow-up inspections can be used to track changes and ensure that the sites are properly designing, implementing, and maintaining BMPs. For programs that have existing data, these data can be used to determine the appropriate baseline factors by which future reductions can be measured. Some potential goals for existing programs may include:

- An increase in BMPs that are effective at removing constituents of concern (e.g., TMDLs), and are suitable to site constraints; and/or
- A reduction in the number of violations.

Planning and Land Development Sources and Activities

Another important aspect of this program element is educating the target audiences associated with the land development requirements – the plan reviewers, engineers, developers, inspectors and BMP owners.

Some example goals, targets (where applicable) and projected timeframes are identified below. The targets and goals in **Table 1** are examples. Each stormwater program will need to decide what numbers are most applicable to their program.

Example Management Questions and Goals

The following questions may also be used to assist in identifying/ establishing goals:

Outcome Level	Management Question
1	Is the program element/control measure/activity being implemented in accordance with the Permit Provisions, SWMP control measures and performance standards?
2	Does the program element/control measure/activity raise the target audience's awareness of an issue?
3	Does the program element/control measure/activity change a target audience's behavior which will result in the proper design and implementation of recommended BMPs?
4	Does the program element/control measure/activity reduce the load of constituents from the sources to the storm drain system?

Planning and Land Development Sources and Activities

Table 1. Example Management Questions, Goals, and Metrics

Program Activity	Management Question	Goal/Metric[2]	Data/Information to be Collected
Outcome Level 4			
Inspections during/after storm events	Was the volume of runoff retained at new development sites?	• 100% of new developments retained the 85th percentile 24-hour storm event, where technically feasible	Track runoff volumes/flows during storm events.
Outcome Level 3			
Inspections	Did inspections change behavior?	• Increase percent of people responding to surveys that they are implementing BMPs to 90% • Increase sites in compliance upon inspection to 75% within 2 years • Increase sites in compliance upon inspection to 90% within 5 years	Track BMP implementation survey results. Track initial site inspection results.
Outcome Level 2			
Plan Review	Did plan review and approval process increase awareness?	• Reduce number of plans that had to make revisions related to land development requirements to <5% within 4 years	Track initial plan review results and required revisions
Training	Was training effective for plan review staff?	• For each training module, increase number of attendees ranking the training as effective to 95% within 5 years • For each training module, increase post-training survey percent of answers correct to 95% within 5 years	Track training evaluation results Track pre- and post-training survey results

[2] It should be recognized that goals and metrics may be limited to TMDL requirements.

This page intentionally left blank

Attachment C

Pollutant Profile Sheets

Bacteria

Mercury

Nutrients

Pesticides

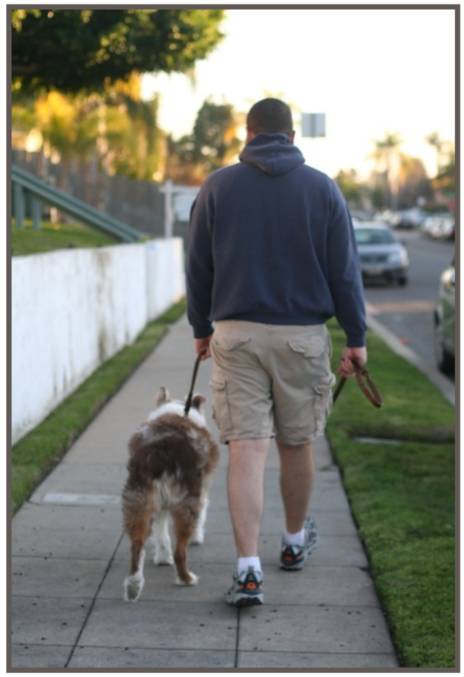
Sediment

Trash

This page intentionally left blank

Bacteria

This fact sheet has been developed to assist stormwater program managers in understanding why this constituent can be problematic in stormwater and urban runoff, what the potential sources are, and how effectiveness assessment goals and metrics can be established to assist program managers in answering specific management questions in order to adaptively manage their programs.



The approach and methods described herein provide a "toolbox" for stormwater program managers so that they can select the program assessment methods and metrics that are most meaningful to their overall stormwater program.

INTRODUCTION

Bacteria naturally exist in the environment, and generally, most types of bacteria present do not cause adverse (i.e., pathogenic) effects to human health, however they are considered indicators of the presence of pathogens. Pathogens are of concern because of the potential for adverse effects to human health upon exposure through consumption or contact with contaminated water.

Many varieties of pathogenic organisms (including bacteria, viruses, and protozoa) exist in quantities so small that it is difficult, costly, and time-consuming to measure. Thus, indicator bacteria, which can be measured using standard laboratory analyses, are used as a surrogate measurement to identify the extent of fecal contamination and presence of other pathogens in a water source. Specifically, the most common indicator bacteria include total coliform bacteria, fecal coliform bacteria, *Escherichia coli* (*E. coli*), and *Enterococci*.

Each stormwater program may also wish to refer to the following source- and activity-specific profiles for additional, example program activities, management questions, goals, and metrics that may apply to this program element:

- Construction
- ✓ Industrial & Commercial
- ✓ Municipal Operations

Bacteria

SOURCES OF BACTERIA

Many bacteria occur naturally in the environment, but indicator bacteria can enter the environment through runoff from areas associated with animal or human activities and wastes. The most common source of bacteria from residential areas is runoff from open spaces contaminated with pets and/or wild animal feces. Less common sources of bacteria from residential areas include improperly working septic systems, faulty or leaking sewer lateral lines, leaking wastewater conveyance systems, sanitary sewer overflows, and illicit sewer connections to stormwater drains.

Agricultural sources, including herding and confined animal feeding operations, are a potential source of highly concentrated bacteria loadings. Uninhibited interactions between cattle and streams, as well as uncontained runoff from confined animal feeding operations entering receiving waters, can have a tremendous impact on the bacteria concentrations of receiving waters. The potential sources of bacteria to receiving waters from various activities are summarized in **Table 1**.

Table 1. Potential Sources of Bacteria

Sources and Activities
Residential Sources
Aging and leaking septic systems Leaking sanitary sewer connections (including laterals) Illicit sewage line connections to storm drains
Industrial/Commercial Sources
Uncontained surface cleaning Waste Handling and Disposal Building and Grounds Maintenance
Municipal Sources
Sanitary sewer overflows
Other Sources
Recreational Activities • Improper waste disposal from boats and/or house boats Agricultural • Close animal and receiving water contact • Improperly maintained and contained waste holding structures

Bacteria

MANAGEMENT QUESTIONS, GOAL SETTING, AND METRIC IDENTIFICATION

As the stormwater program is developed, it is important that the program manager considers how the program will be able to answer critical management questions (both environmental and programmatic), and incorporate measureable, achievable goals and corresponding metrics that are consistent with the program's priorities. Example management questions and the corresponding goals and metrics specific to bacteria are provided below. However, each stormwater program manager will need to decide what management questions and goals are most applicable to and in alignment with their program's priorities.

Example Bacteria-Related Management Questions and Goals

The management questions identified below are examples of the types of questions that a program can be designed to assist in answering. The questions are designed to assist program managers in adaptively managing their programs so that they can prioritize their resources.

Outcome Level	Management Question
6	Are impacted waterways meeting the TMDL targets for indicator bacteria as specified in the applicable TMDL(s)?
5, 6	Are the urban stormwater dischargers a significant source of indicator bacteria to the receiving waters? Are there other sources that are major contributors?
5	Are the Permittees meeting the load allocations for indicator bacteria as specified in the applicable TMDL(s)?
2 to 4	Are the Permittees effectively implementing BMPs that target bacteria indicators?

Table 3 provides example management questions, goals and metrics for outcome levels 2-4.

Bacteria

Table 3. Example Program Activities, Management Questions, Goals, and Metrics

Program Activity	Management Question	Goal/Metric[1]	Data/Information to be Collected
Residential Operations			
Develop educational materials with information regarding sources of bacteria. Update the website. Provide these materials at outreach events, etc.	Is the general public aware of the need to properly dispose of pet waste and are they doing so?	Based on survey results, 20-25% of the residents are aware of the need to properly dispose of pet waste. Based on survey results, 20-25% % of the residents are reporting that they are disposing of pet waste correctly.	Identify the source(s) of information for the residents (pet waste signs, PSAs, brochures, community events, dog tag licensing, etc.)
Provide outreach to houseboat owners/residents.	Are houseboat owners aware of the need to properly dispose of sump waste, and are they doing so?	20-25% of the houseboat owners are aware of the need to properly dispose of sump waste. 20-25% of the houseboat owners are reporting that they are disposing of sump waste correctly.	Surveys conducted at marinas and marine/boat supply stores.
Industrial/Commercial Operations			
Inspect facilities with the potential to contribute bacteria.	Are the industrial and commercial sites that could release bacteria aware of the BMPs that they should be implementing on for waste handling and disposal and surface cleaning, and are they implemented and maintained?	90-100% of the facilities are aware of the need to implement the necessary BMPs and are doing so. 90-100% are reporting that they are implementing BMPs.	Review inspection results and/or conduct surveys.

[1] It should be recognized that goals and metrics may be limited to TMDL requirements.

Bacteria

Program Activity	Management Question	Goal/Metric[1]	Data/Information to be Collected
Municipal Operations			
Inspect facilities with the potential to contribute bacteria (animal shelters, kennels, etc.).	Are the sites that may contribute bacteria aware of the BMPs that they should be implementing either on site or as part of their services, and are they implemented and maintained?	90-100% of the facilities are aware of the need to implement the necessary BMPs and are doing so. 90-100% are reporting that they are implementing BMPs.	Track inspection results and/or conduct surveys. Conduct audits of contracted services.
Coordinate with the sanitation district/agency for responses to sanitary sewer overflows	Are the reported sanitary sewer overflows (SSOs) potentially impacting the storm drains and/or receiving waters?	Based on the SSOs reported, <25% of the SSOs are reaching the storm drains or receiving waters.	Evaluate the estimated gallons and locations of impacts from SSO reports for the municipality compared to monitoring data

This page intentionally left blank

Mercury

This fact sheet has been developed to assist stormwater program managers in understanding why this constituent can be problematic in stormwater and urban runoff, what the potential sources are, and how effectiveness assessment goals and metrics can be established to assist program managers in answering specific management questions in order to adaptively manage their programs.

The approach and methods described herein provide a “toolbox” for stormwater program managers so that they can select the program assessment methods and metrics that are most meaningful to their overall stormwater program.

INTRODUCTION

Mercury is primarily a concern because of the highly toxic and bioaccumulative nature of its methylated state, methylmercury. In the environment, mercury naturally cycles among its elemental, ionic, and methylated forms. Once mercury is released, local environmental conditions determine its transformations. Bacteria that process sulfate in the environment can take up mercury in its inorganic form and, through metabolic processes, convert it to methylmercury. Factors such as dissolved oxygen, pH, nutrient, sulfide, and sulfate concentrations may affect methylation rates.[1] Concentrations of methylmercury increase as it traverses the food web—from primary producers to higher trophic level fish to wildlife and humans—thereby causing a greater risk to consumers at the highest trophic level. Methylmercury is a neurotoxin that affects the brain and central nervous system, with long term exposure leading to loss of physical coordination and mental deficiencies. Developing fetuses and young children are most susceptible to its toxic effects.

Each stormwater program may also wish to refer to the following source- and activity-specific profiles for additional, example program activities, management questions, goals, and metrics that may apply to this program element:

- Construction
- ✓ Industrial & Commercial
- Municipal Operations

SOURCES OF MERCURY

Mercury enters the environment through natural sources, such as the natural breakdown of minerals in rocks and soils, as well as human activities such as mining, the burning of fossil fuels, and consumer

[1] USEPA (1997) Mercury Study Report to Congress, Volumes I through VIII. In: Office of Air Quality Planning and Standards and ORD. EPA/452/R-97-001. December.

product use. Mercury from these sources enters waterways through atmospheric deposition and direct contamination of water and sediment entering waterways. The potential sources of mercury are summarized in **Table 1**.

Mercury has useful properties which have been applied in many products and applications historically, and it is still widely used (**Table 2**). Thermometers, barometers, and other scientific instruments can contain mercury. Mercury vapor is used in streetlights, fluorescent light bulbs, computer equipment and advertising signs. Its ability to easily form amalgams with other metals such as gold, silver, zinc, and cadmium led to use of mercury in dental fillings and dry cell batteries. Mercury can form compounds with other elements to create cleaning chemicals, disinfectants, and paints. Improper disposal of these chemicals can contribute mercury directly to wastewater, stormwater, and the atmosphere.

Table 1. Potential Sources of Mercury

Sources and Activities
Residential Sources
Household products
Improper disposal of mercury-containing products
Industrial/Commercial Sources
Chemicals
Combustion
Manufacturing
Production
Dental offices
Hospitals
Laboratories
Medical clinics
Secondary schools
Universities
Vehicle service facilities
Other Sources
Atmospheric deposition
Legacy sources (i.e., mining)

Table 2. Common Mercury-Containing Products for Consumer and Commercial Uses

Mercury

Product Type	Mercury-Containing Products
Consumer Products	
Household Items	Airflow/thermostat controls, antique instruments (barometers, mirrors, organs), appliances, button cell batteries, clothes irons, light switches, latex paint, tilt switches, fluorescent light bulbs
Medical Pharmaceutical Products	Thimerosal (preservative in vaccines, antibiotics), contact lens solution, dental amalgam, thermometers, ear and eye drops, skin cream
Automotive Parts	Switches in pre-2003 cars: light switches, heated car rear windows, acceleration sensors, school bus braking systems; switches in new cars' navigation screens and HID headlights
Commercial Products	
Medical Products	Antibiotics, batteries, alarms, blood pressure cuffs, hearing aids, pacemakers, scales, ultrasound, tubes, vaccines
Electrical Products	Tilt switches, security systems, pressure controls, silent light switches, temperature control, thermometers, laptop computers, computer monitors
Manufacturing Products	Laboratory reagents (i.e., mercury chloride, mercury iodide, mercury nitrate, Hitachi Chem Analyzer reagent, Golgi's, Takata's reagent)

MANAGEMENT QUESTIONS, GOAL SETTING, AND METRIC IDENTIFICATION

As the stormwater program is developed, it is important that the program manager considers how the program will be able to answer critical management questions (both environmental and programmatic), and incorporate measureable, achievable goals and corresponding metrics that are consistent with the program's priorities. Example management questions and the corresponding goals and metrics specific to mercury are provided below. However, each stormwater program manager will need to decide what management questions and goals are most applicable to and in alignment with their program's priorities.

Mercury

Example Mercury-Related Management Questions and Goals

The management questions identified below are examples of the types of questions that a program can be designed to assist in answering. The questions are designed to assist program managers in adaptively managing their programs so that they can prioritize their resources.

Outcome Level	Management Question
6	Are impacted waterways meeting the TMDL targets for methylmercury as specified in the applicable TMDL(s)?
5, 6	Are the urban stormwater dischargers a significant source of total and/or methylmercury to the receiving waters? Are there other sources that are major contributors?
5	Are the Permittees meeting the load allocations for methylmercury as specified in the applicable TMDL(s)?
2 to 4	Are the Permittees effectively implementing BMPs that target mercury and/or prevent the creation of methylmercury?

Table 3 provides example management questions, goals and metrics for outcome levels 2-4.

Mercury

Table 3. Example Program Activities, Management Questions, Goals, and Metrics

Program Activity	Management Question	Goal/Metric[2]	Data/Information to be Collected
Residential Operations			
Develop educational materials with information regarding mercury. Update the website. Provide these materials at outreach events, etc.	Is the general public aware of the need to properly dispose of mercury-containing products at the local household hazardous waste (HHW) facility?	20-25% of the residents are aware of the need to properly dispose of mercury-containing products at the local HHW facility. 50% are aware of alternative products that don't contain mercury like digital thermometers.	Survey results using questions regarding awareness of proper disposal and existence of HHW facility Identify the source(s) of information for the residents (public service announcements (PSAs), brochures, community events, HHW facility, etc.)
Implementation of a program for diverting mercury-containing waste products (e.g., thermometers and gauges, batteries, fluorescent and other lamps, switches, relays, sensors, and thermostats) from the waste stream	Is the general public using the local HHW?	20-25% of the residents are reporting that they are disposing of mercury-containing products at the local HHW facility. Examples of such products include thermometers and other gauges, batteries, fluorescent and other lamps, switches, relays, sensors and thermostats.	Survey results using questions regarding reported use of HHW. Track how many people using HHW are turning in mercury containing products. How many mercury-containing products are turned in on an annual basis to the local HHW facility? What is the breakdown of the types of items collected at the centers?
Implementation of a public participation program, including cleanup events	Is the general public improperly disposing of mercury-related trash?	Less than 5% of the debris removed from local water ways during cleanup events contain mercury.	How much of the trash/debris that was collectively removed from the local waterways as a part of stream cleanup events was debris that contains mercury (e.g., thermometers,

[2] It should be recognized that goals and metrics may be limited to TMDL requirements.

Mercury

Program Activity	Management Question	Goal/Metric[2]	Data/Information to be Collected
			fluorescent lights, oil-based paints, appliances with mercury switches)?
Industrial/Commercial Operations			
Inspect facilities and/or activities with the potential to contribute mercury	Are the industrial and commercial sites that use, store, or could generate mercury aware of the BMPs that they should be implementing on site, and are they implemented and maintained?	Based on the results of inspections, 90-100% of the facilities are aware of the need to implement the necessary BMPs and are doing so. For example, facilities are using alternative products that do not contain mercury and are disposing of mercury containing products as hazardous waste.	Inspection results tracking BMPs.
Municipal Operations			
Inspect facilities and/or activities with the potential to contribute mercury.	Are the facilities that use, store, or could generate mercury aware of the BMPs that they should be implementing on site, and are they implemented and maintained?	Based on the results of inspections, 90-100% of the facilities are aware of the need to implement the necessary BMPs and are doing so. For example, facilities are using alternative products that do not contain mercury and are disposing of mercury containing products as hazardous waste.	Inspection results tracking BMPs. Conduct surveys with municipal staff.

Nutrients

This fact sheet has been developed to assist stormwater program managers in understanding why this constituent can be problematic in stormwater and urban runoff, what the potential sources are, and how effectiveness assessment goals and metrics can be established to assist program managers in answering specific management questions in order to adaptively manage their programs.

The approach and methods described herein provide a "toolbox" for stormwater program managers so that they can select the program assessment methods and metrics that are most meaningful to their overall stormwater program.

INTRODUCTION

The term "nutrients" primarily refers to nitrogen and phosphorous. In water bodies, small amounts of nutrients are needed to grow healthy sea grass, algae, and other forms of aquatic plant life. If too many nutrients are added, however, plant growth is over-stimulated, which can result in an adverse impact to the health of the aquatic environment. Nutrient enrichment (i.e., eutrophication) can lead to reduced water clarity and increased presence of undesirable algae. In addition, algae respiration and decay depletes oxygen from the water column, potentially creating an impaired aquatic environment and often causing nuisance odors. Nutrient levels in water bodies are typically evaluated based on nitrogen and phosphorus concentrations as these represent the primary constituents of concern.

Each stormwater program may also wish to refer to the following source- and activity-specific profiles for additional, example program activities, management questions, goals, and metrics that may apply to this program element:

- Construction
- ✓ Industrial & Commercial
- ✓ Municipal Operations

SOURCES OF NUTRIENTS

Sources of nutrients in freshwater and coastal areas are diverse and can include agricultural runoff, leaching of septic tanks, municipal and industrial wastewater, urban stormwater runoff, runoff from open space, and fossil fuel combustion. In the urban environment, nutrient concentrations in stormwater may be elevated, often caused by runoff from over-fertilized lawns and landscaped areas, leaf litter and detritus, and/or suspended solids. In agricultural areas, commercial fertilizers and animal manure are typically the primary sources of nutrients in waterways, while wastewater and stormwater flows are primary sources of nutrients in urban waterways. The potential sources of nutrients are summarized in **Table 1**.

Nitrogen and phosphorus are the main ingredients in fertilizers, which are widely applied in agricultural and residential areas. Historically, they have also been used in detergents and cleaning products, although they are being phased out for these applications. Major uses of these constituents are summarized in **Table 2**.

Nutrients

Table 1. Potential Sources of Nutrients (Nitrogen and Phosphorus)

Sources and Activities
Residential Sources
Lawn and gardening fertilizers
Car washing
Pet waste
Septic tanks
Industrial/Commercial Sources
Nurseries
Landscaping businesses
Commercial laundries
Car washes
Municipal Sources
Lawn and gardening fertilizers
Car washing
Pet waste
Septic tanks
Other Sources
Agricultural • Animal wastes, especially from confined animal feeding operations • Over-fertilized agricultural areas
Open space runoff and bank erosion (especially during storms)
Leaf litter and detritus
Groundwater infiltration

Table 2. Common Nutrient-Containing Products for Consumer and Commercial Uses

Product Type	Nutrient-Containing Products
Consumer Products	
Household Items	Detergents and cleaning chemicals
Landscaping Products	Fertilizers and soil-enrichment/gardening supplements

Nutrients

MANAGEMENT QUESTIONS, GOAL SETTING, AND METRIC IDENTIFICATION

As the stormwater program is developed, it is important that the program manager considers how the program will be able to answer critical management questions (both environmental and programmatic), and incorporate measureable, achievable goals and corresponding metrics that are consistent with the program's priorities. Example management questions and the corresponding goals and metrics specific to nutrients are provided below. However, each stormwater program manager will need to decide what management questions and goals are most applicable to and in alignment with their program's priorities.

Example Nutrient-Related Management Questions and Goals

The management questions identified below are examples of the types of questions that a program can be designed to assist in answering. The questions are designed to assist program managers in adaptively managing their programs so that they can prioritize their resources.

Outcome Level	Management Question
6	Are impacted waterways meeting the TMDL targets for nutrients (usually expressed as nitrogen and phosphorus) as specified in the applicable TMDL(s)?
5, 6	Are the urban stormwater dischargers a significant source of nutrients (usually expressed as nitrogen and phosphorus) to the receiving waters? Are there other sources that are major contributors?
5	Are the Permittees meeting the load allocations for nutrients (usually expressed as nitrogen and phosphorus) as specified in the applicable TMDL(s)?
2 to 4	Are the Permittees effectively implementing BMPs that target nutrient reduction in the waterways?

Table 3 provides example program activities, management questions, goals and metrics for outcome levels 2-4.

Nutrients

Table 3. Example Program Activities, Management Questions, Goals, and Metrics

Program Activity	Management Question	Goal/Metric[1]	Data/Information to be Collected
Residential Operations			
Develop educational materials with information regarding nutrients. Update the website. Provide these materials at home and gardening stores, nurseries, outreach events, etc.	Is the general public aware of proper nutrient management practices (e.g., do not overuse fertilizer; sweep, do not hose, sidewalks and driveways; sweep leaves and detritus away from storm drains, wash cars on lawns, not driveways)?	Based on survey results, 80-100% of the residents are aware of proper landscaping practices that help minimize stormwater pollution. Based on survey results, 80-100% of the residents are reporting that they are implementing these practices	Identify the source(s) of information for the residents (public service announcements (PSAs), brochures, community events, outreach at home and gardening stores, etc.)
Industrial/Commercial Operations			
Inspect facilities with the potential to contribute nutrients: • Nurseries • Landscaping • Car washes • Golf Courses • Cemeteries	Are the sites that may contribute nutrients aware of the BMPs that they should be implementing either on site or as part of their services, and are they implemented and maintained?	90-100% of the facilities are aware of the need to implement the necessary BMPs and are doing so. For example, car washing facilities are using phosphate-free detergents and capture, treat, and recycle all of their water, or landscaping businesses are regularly training employees on proper watering practices and fertilizer application.	Track inspection results and/or conduct surveys.

[1] It should be recognized that goals and metrics may be limited to TMDL requirements.

Nutrients

Program Activity	Management Question	Goal/Metric[1]	Data/Information to be Collected
Municipal Operations			
Inspect facilities with the potential to contribute nutrients: • Parks • Landscaping	Are the sites that may contribute nutrients aware of the BMPs that they should be implementing either on site or as part of their services, and are they implemented and maintained?	90-100% of the facilities are aware of the need to implement the necessary BMPs and are doing so. For example, parks and contract landscaping services are regularly training employees on proper watering practices and fertilizer application.	Track inspection results and/or conduct surveys. Conduct audits of contracted services.
Maintenance of the municipally owned and operated landscape and right of way	Are the Permittees actively managing municipal use of fertilizers on right-of-way and other landscaped areas?	The total amount of fertilizers applied is being reduced by 50% over 5-10 years. The total amount of acreage to which fertilizers are applied is being reduced by 20% over 5-10 years. Of the total municipally owned and operated landscaped acreage, 20-30% is being managed with practices that reduce or eliminate fertilizer use (e.g., efficient watering, landscape planning, use of native plants, soil testing, composted organic material).	How many acres is fertilizer used on, and what approaches are used? How much fertilizer is used for the applications?

Pesticides

This fact sheet has been developed to assist stormwater program managers in understanding why pesticides can be problematic in stormwater and urban runoff, what the potential sources are, and how effectiveness assessment goals and metrics can be established to assist program managers in answering specific management questions in order to adaptively manage their programs.

The approach and methods described herein provide a "toolbox" for stormwater program managers so that they can select the program assessment methods and metrics that are most meaningful to their overall stormwater program.

INTRODUCTION

The term "pesticides" includes herbicides, fungicides, rodenticides, biocides, and insecticides. Pesticides are intended to be toxic to unwanted pests but can also be harmful to people, pets and the environment. Some pesticides (primarily historic pesticides) tend to persist in the environment and, in fact, pesticides that have been banned for decades (e.g., DDT) are still found in urban waterbodies, especially in sediments. Modern pesticides have been linked to widespread toxicity to sensitive organisms in California's urban watersheds.

The primary pesticides currently of concern in California urban water bodies are the pyrethroids and fipronil, both insecticides used widely for structural pest control. Pyrethroids almost completely replaced the organophosphate pesticides diazinon and chlorpyrifos, which have been phased out for almost all urban uses. Fipronil use has been on the rise in recent years, and monitoring has shown it to be a problem in urban waters as well. Other pesticides of interest include indoxacarb (another insecticide increasing in use in urban areas), the herbicide diuron, and biocides like chlorine and copper that are used in swimming pools and outdoor building materials.

Each stormwater program may also wish to refer to the following source- and activity-specific profiles for additional, example program activities, management questions, goals, and metrics that may apply to this program element:

- ✓ Construction
- ✓ Industrial & Commercial
- ✓ Municipal Operations

Pesticides

SOURCES OF PESTICIDES

In urban areas, the main categories of outdoor pesticide use are structural pest control (primarily insecticides), landscaping (mostly herbicides and fungicides, some insecticides), right-of-way maintenance (herbicides), swimming pools/spas/fountains (biocides), and building materials (biocides like wood and paint preservatives). By far, the most problematic uses from a stormwater quality perspective are outdoor structural applications of insecticides, primarily to control Argentine ants that invade buildings. Prior to the discontinuation of their registration for almost all urban uses, diazinon and chlorpyrifos were the primary insecticides used to control these ants. Pyrethroids and fipronil are currently the dominant chemicals used outdoors for structural pest control. In 2012 the California Department of Pesticide Regulation (DPR) adopted regulations to address the problem of pyrethroids. DPR is evaluating the effectiveness of the pyrethroid regulations, and in 2015 has begun to develop approaches to mitigate the fipronil problem. *For outdoor uses, fipronil is only available for structural applications by licensed professionals.*

Although pesticide use and sales data indicate that large amounts of a wide variety of herbicides and fungicides are applied in outdoor urban settings by both residents and professionals, with the exception of diuron, monitoring data does not implicate them as a widespread cause of impairment in urban receiving waters in California. Biocides in pool, spa, and fountain discharges have been linked to fish kills in creeks. A few biocides, like copper swimming pool additives and wood preservatives, contribute to copper impairments that stem from both pesticide and non-pesticide sources. The potential sources of pesticides are summarized in **Tables 1** and **2**.

Pesticides

Table 1. Potential Sources of Pyrethroids and Fipronil in Urban Runoff

Sources and Activities
Construction Sources
Key Source: Pre-construction termiticide treatment of soil. Done by licensed pest control operators, prior to pouring of concrete slabs and foundations.
Residential Sources
Key Source: Outdoor structural pest control, mostly by licensed pest control operators (primarily for Argentine ants). Landscaping insect applications (much lower amount than for structural; Applications to pervious surfaces much less likely to mobilize in runoff).
Industrial/Commercial Sources
Key Source: Outdoor structural pest control, mostly by licensed pest control operators (outdoor, primarily for cockroaches and other insects associated with restaurants; some Argentine ant control around office buildings) Commercial nurseries
Municipal Sources
Outdoor structural pest control, mostly by licensed pest control operators (office buildings, transfer stations) Vector control. Mosquitoes, fire ants, yellow jackets (Vector control is often done by special districts, not cities or counties)

Table 2. Other Pesticide Uses in Urban Areas

Other Pesticide Uses by Source
Residential Sources
Landscaping: broadleaf and pre-emergent control in turf areas (2,4D; oryzalin); weed control (glyphosate, many others) in hardscape crevices, fencelines, tree wells, planting beds; some insecticide use for fire ants (So. Calif.) ; lawns (often unnecessary scheduled applications); nuisance honeydew producers; various landscape pests
Building materials: treated wood, roof shingles, outdoor paint (biocides)
Swimming pool, spa, and fountain water (if drained to storm drains) (chlorine, copper, PHMB, many others)
Industrial/Commercial Sources
Herbicides used for weed control for turf, paved areas, fencelines.
Cooling water system discharges (if drained to storm drains) (copper and other biocides)
Golf courses: broadleaf control in turf areas, fungicides and insecticides (greens)
Municipal Sources
Herbicides used for vegetation control in rights of way: drainage facilities, roadsides,
Rodenticides for burrowing rodents
Corporation yards: Herbicides for weed control
Treated wood (pentachlorophenol, copper, and other wood preservatives)
Street tree pests: Insecticides for honey dew producers, defoliators (elm leaf beetles)
Parks: tree wells, fence lines,
Vector control: rats

Pesticides

CASQA Pesticide Strategy

In California, municipalities do not have the authorities necessary to prevent pesticides from occurring in their stormwater discharges. Under State and federal pre-emptions, municipalities cannot control pesticide labels, they cannot regulate pesticide users, and they cannot determine which pesticides can be sold in their cities. As such, the tools available to local stormwater agencies to control pesticide discharges are limited to control of municipal operation uses and public outreach programs. While such efforts should be part of a comprehensive pesticide control strategy, they are not likely to reduce the application of widely-used currently registered pesticides, such as pyrethroids, such that they are not causing water quality impairments.

CASQA's strategy for addressing pesticide water quality problems is based on the statutory authority already possessed by State and federal pesticide regulators to protect the state's surface waters. Since the mid-1990s, CASQA (and its predecessor organization) has been working closely with the State Water Resources Control Board, multiple Regional Water Quality Control Boards, the Department of Pesticide Regulation (DPR), and federal pesticide regulators at USEPA toward achieving the goal of eliminating pesticide-related water pollution in California's urban waterways.

Significant progress has been made toward improving how pesticides are regulated, most notably the surface water protection regulations adopted by DPR, which establish restrictions on pyrethroid applications by licensed applicators. Other achievements include pyrethroid label restrictions, and improvements in how USEPA evaluates, at least for some pesticides, the potential for urban water quality impacts during the registration process.

MANAGEMENT QUESTIONS, GOAL SETTING, AND METRIC IDENTIFICATION

As the stormwater program is developed and implemented, it is important that the program manager considers how the program will be able to answer critical management questions (both environmental and programmatic), and incorporate measureable, achievable goals and corresponding metrics that are consistent with the program's priorities. Example management questions and the corresponding goals and metrics specific to pesticides are provided below. However, each stormwater program manager will need to decide what management questions and goals are most applicable to and in alignment with their program's priorities.

Example Pesticide-Related Management Questions and Goals

The management questions identified below are examples of the types of questions that a program can be designed to assist in answering. The questions help program managers in adaptively managing their programs so that they can prioritize their resources.

Outcome Level	Management Question
The CASQA Pesticides Subcommittee intends to implement actions to address the following questions through its annual workplan and its annual reports:	
5 to 6	Are actions being taken by State and Federal pesticides regulators and stakeholders that are expected to end recently observed pesticide-caused toxicity or exceedances of pesticide water quality objectives in surface waters receiving urban runoff? [Near-term/Current Problems]
2 to 6	Do pesticides regulators have an effective system in place to exercise their regulatory authorities to prevent pesticide toxicity in urban water bodies? [Long-term/Prevent Future Problems]
CASQA's Pesticides Subcommittee is implementing actions addressing the following questions through its annual workplan and potentially in a new annual monitoring report if funding becomes available. These questions may be answered utilizing primarily statewide representative monitoring conducted by DPR and the Water Boards (SWAMP), complemented by applicable, representative MS4 data. Other applicable data could be considered as well.	
5 6	Do water column samples or sediments in surface waters receiving urban runoff exhibit toxicity to standard test organisms that is caused by pesticides in urban runoff?
6	How do conditions in surface waters receiving urban runoff compare with EPA pesticides benchmarks and pesticides water quality objectives?
5	Do urban runoff discharges achieve pesticide TMDL allocations?
General questions related to management outcomes within permittees' individual control:	
2 to 4	Do the Permittees have and are implementing in-house IPM policies and contracting requirements that reduce the use of pyrethroids, fipronil, and other insecticides at municipal facilities by staff and/or pest management vendors?
2 to 4	Does the Permittee have and are implementing a program to direct swimming pool, spa, fountain, and cooling water system discharges to the sanitary sewer?
2 to 4	Are the Permittees effectively implementing outreach and education programs that target pesticides?

Pesticides

Table 3. Example Program Activities, Management Questions, Goals, and Metrics

Program Activity	Management Question	Goal/Metric[1]	Data/Information to be Collected
Residential Operations			
For problem pesticides, use federal pesticide registration and labeling authority to limit availability to the public. *[Anticipated to be addressed by CASQA Pesticide Subcommittee]*	Does legal application of this pesticide by residents in urban areas result in toxicity in urban water bodies?	Pesticide regulators and manufacturers have established product labels that effectively limit the use of the pesticide by the public. Modeling by USEPA supports label changes.	Relative contribution of residential use to the problem. Runoff characteristics, fate and transport of pesticide and its degradates, test organism toxicity.
Develop educational materials with information regarding pesticides. Update the website. Provide these materials at home and gardening stores, nurseries, outreach events, etc.	Is the general public aware of the need to reduce the use of pesticides and use IPM[2] based approaches for the control of pests?	Based on survey results, 20-25% of the residents are aware of the need to reduce pesticide use. Based on survey results, 20-25% of the residents are reporting that they are using IPM-based approaches. Based on survey results less than 30% of the residents reported using pesticides within the past year.	Identify the source(s) of information for the residents (public service announcements (PSAs), brochures, community events, outreach at home and gardening stores, etc.)

[1] It should be recognized that goals and metrics may be limited to TMDL requirements.

[2] IPM encourages alternative pest-management approaches to reduce the use of pesticides along with best management practices to apply necessary pesticides in ways that reduce runoff into stormwater.

Pesticides

Program Activity	Management Question	Goal/Metric[1]	Data/Information to be Collected
Industrial/Commercial Operations			
Use state and federal pesticide regulations to require mitigation of applications by licensed pesticide applicators. *[Anticipated to be addressed by CASQA Pesticide Subcommittee]*	Does legal application of this pesticide by licensed applicators in urban areas result in toxicity in urban water bodies?	Pesticide regulators and manufacturers have established State or federal pesticide label and licensed applicator requirements that will reduce runoff sufficiently to prevent impacts to urban water bodies. Modeling predicts effectiveness of mitigation measures.	Pesticide use data, runoff characteristics, fate and transport of pesticide and its' degradates, test organism toxicity. Data from enforcement, pesticide use reports, and surveillance monitoring of water bodies will measure effectiveness of regulation.
Inspect facilities with the potential to contribute pesticides: Nurseries Landscaping Golf Courses Cemeteries	Are the sites that may contribute pesticides aware of the BMPs that they should be implementing either on site or as part of their services, and are they implemented and maintained?	90-100% of the facilities are aware of the need to implement the necessary BMPs and are doing so. For example, landscaping businesses are regularly training employees on IPM, proper watering practices, and pesticide application.	Track inspection results and/or conduct surveys.
Integrated pest management (IPM) for commercial sites	Are the group of local businesses that are likely to use pesticides aware of IPM methods and certification programs that are available to them?	90-100% of the facilities are aware of IPM certification programs such as GreenPro, EcoWise, and eco-friendly landscaping.	Track inspection results and/or conduct surveys.

Pesticides

Program Activity	Management Question	Goal/Metric[1]	Data/Information to be Collected
Municipal Operations			
Inspect municipal facilities with the potential to contribute pesticides: Parks Landscaping	Are the sites that may contribute pesticides aware of the BMPs that they should be implementing either on site or as part of their services, and are they implemented and maintained?	90-100% of the facilities are aware of the need to implement the necessary BMPs and are doing so. For example, parks and contract landscaping services are regularly training employees on IPM, proper watering practices, and pesticides application.	Track inspection results and/or conduct surveys. Conduct audits of contracted services.
Structural pest control around municipal buildings.	Has the agency minimized use of pyrethroids around its buildings?	Establish IPM certification requirements, such as GreenPro and EcoWise, for structural pest management vendors.[3]	Does vendor contract require IPM certified services? Does vendor possess IPM certification? Is the vendor actually delivering IPM services according to certification standards? Is vendor using pyrethroids and fipronil around municipal facilities? What are the amounts of pyrethroids and fipronil being applied [active ingredient]?

[3] Green Pro (www.certifiedgreenpro.org) and EcoWise Certified (www.ecowisecertified.org) are independent Integrated Pest Management certification programs for licensed structural pest control businesses.

Pesticides

Program Activity	Management Question	Goal/Metric[1]	Data/Information to be Collected
Implementation of a municipal integrated pest management (IPM) program as a part of the overall maintenance of the municipal owned and operated landscape and right of way	Are the Permittees actively implementing the IPM program and actively managing municipal use of pesticides on public rights-of-way and other landscaped areas?	The IPM program is being implemented. The total amount of pesticides applied to public rights-of-way, parks, and other landscaped areas (as measured by active ingredient) is being reduced by 30% in 5-10 years.	Is there an agency-wide IPM program in place? Are activity-specific IPM practices documented? How many acres is IPM used on, and what approaches are used? How much total active ingredient is used for the pesticides applications?
Collection of pesticide waste at HHW sites.	Is the general public aware of the need to properly dispose of pesticide-containing products at the local HHW collection center, and are they doing so?	20-25% of the residents are aware of the need to properly dispose of pesticide-containing products at the local HHW collection center. 20-25% of the residents are reporting that they are disposing of pesticide-containing products at the local HHW collection center.	Track the quantity of pesticide-containing products turned in on an annual basis to the local HHW collection center. Determine the breakdown of the items collected. Identify the source(s) of information for the residents (public service announcements [PSAs], brochures, community events, “Our Water Our World” campaign [OWOW][4], etc.

[4] Private-public partnership between local stormwater agencies and garden and hardware stores to encourage the use of less toxic products and proper disposal of pesticides.

This page intentionally left blank

Sediment

This fact sheet has been developed to assist stormwater program managers in understanding why this constituent can be problematic in stormwater and urban runoff, what the potential sources are, and how effectiveness assessment goals and metrics can be established to assist program managers in answering specific management questions in order to adaptively manage their programs.

The approach and methods described herein provide a “toolbox” for stormwater program managers so that they can select the program assessment methods and metrics that are most meaningful to their overall stormwater program.

INTRODUCTION

Sediment is a natural component of stormwater. Sediment resulting from excessive erosion is a pollutant. Sediment can be detrimental to aquatic life (primary producers, benthic invertebrates, and fish) by interfering with photosynthesis, respiration, growth, reproduction, and oxygen exchange in water bodies. Sediment can transport other pollutants that are attached to it including nutrients, trace metals, and hydrocarbons. Sediment is the primary component of turbidity, total suspended solids (TSS), and Suspended Sediment Concentration (SSC), common water quality analytical parameters.

SOURCES OF SEDIMENT

Soil erosion, either natural or due to construction or other deliberate activities, is the process by which soil particles are detached by water, wind, or gravity. Sediment resulting from erosion enters waterways primarily through runoff. Runoff from agricultural fields and construction operations can carry high sediment loads because these operations expose the soil surfaces. Within an urban setting, runoff from commercial landscaping or residential yards and gardens with exposed or newly-tilled soil may carry sediment to the storm drain system. Certain types of residential or commercial operations may be a source of sediment. Minor construction and maintenance

Each stormwater program may also wish to refer to the following source- and activity-specific profiles for additional, example program activities, management questions, goals, and metrics that may apply to this program element:

- ✓ Construction
- ✓ Industrial & Commercial
- ✓ Municipal Operations

activities may be source if soil surfaces are exposed. Illicit discharges from commercial/industrial operations such as nurseries could result in sediment releases to the storm drain. The potential sources of sediment are summarized in **Table 1**.

Table 1. Potential Sources of Sediment

Sources and Activities
Construction Sources
Construction site erosion
Residential Sources
Yard and garden runoff
Roof runoff (from dust)
Industrial/Commercial Sources
Illicit discharges/Illegal connections
• Vegetable washing/ food processing
• Car washing
• Mobile surface cleaning
Unpaved operations and storage yards
Nurseries
Animal boarding facilities
Landscaping runoff
Municipal Sources
Road runoff
Corporation yards
Road maintenance
Landscape runoff
Parks and playfields
Other Sources
Agricultural runoff
Streambed and bank erosion due to hydromodification
Natural erosion

Sediment

MANAGEMENT QUESTIONS, GOAL SETTING, AND METRIC IDENTIFICATION

As the stormwater program is developed, it is important that the program manager considers how the program will be able to answer critical management questions (both environmental and programmatic), and incorporate measureable, achievable goals and corresponding metrics that are consistent with the program's priorities. Example management questions and the corresponding goals and metrics specific to sediment are provided below. However, each stormwater program manager will need to decide what management questions and goals are most applicable to and in alignment with their program's priorities.

Example Sediment-Related Management Questions and Goals

The management questions identified below are examples of the types of questions that a program can be designed to assist in answering. The questions are designed to assist program managers in adaptively managing their programs so that they can prioritize their resources.

Outcome Level	Management Question
6	Are impacted waterways meeting the TMDL targets for sediment as specified in the applicable TMDL(s)?
5, 6	Are the urban stormwater dischargers a significant source of sediment to the receiving waters? Are there other sources that are major contributors?
5	Are the Permittees meeting the load allocations for sediment as specified in the applicable TMDL(s)?
2 to 4	Are the Permittees effectively implementing BMPs that target sediment reduction in the waterways?

Table 2 provides example management questions, goals and metrics for outcome levels 2-4.

Sediment

Table 2. Example Program Activities, Management Questions, Goals, and Metrics

Program Activity	Management Question	Goal/Metric[1]	Data/Information to be Collected
Construction Operations			
Inspect sites	Are construction sites being managed so that they are in compliance with the local codes and ordinances and preventing sediment from leaving the site?	>85% of the construction sites are in compliance and are implementing and maintaining the necessary BMPs on site. 100% of sites where a sediment control deficiency was identified were corrected by the re-inspection.	Inspection results
Residential Operations			
Develop educational materials with information regarding sediment. Update the website. Provide these materials at outreach events, etc.	Is the general public aware of proper sediment management practices (e.g., sweep, do not hose, sidewalks and driveways; wash cars on lawns, not driveways)?	20-25% of the residents are aware of proper landscaping practices that help minimize runoff and sediment in runoff. 20-25% of the residents are reporting that they are implementing these practices.	Survey results Identify the source(s) of information for the residents (public service announcements (PSAs), brochures, community events, etc.)
Industrial/Commercial Operations			
Inspect facilities with the potential to contribute sediment.	Are commercial and industrial sites being managed so that they are in compliance with the local codes and ordinances and preventing sediment from	Greater than 90% of the sites are in compliance and are implementing and maintaining the necessary BMPs on site	Inspection results

[1] It should be recognized that goals and metrics may be limited to TMDL requirements.

Sediment

Program Activity	Management Question	Goal/Metric[1]	Data/Information to be Collected
	leaving the site?		
Municipal Operations			
Inspect facilities with the potential to contribute sediment.	Are the municipal facilities that could generate sediment aware of the BMPs that they should be implementing on site, and are they implemented and maintained?	90-100% of the facilities are implementing the necessary BMPs.	Track inspection results and/or conduct surveys. Conduct audits for contracted services
Implement a street sweeping and catch basin cleaning program.	How much material is removed in the street sweeping program? How much material is removed in the catch basin cleaning program?	Regular *[specify stormwater program's frequency]* street sweeping is being implemented to remove sediment from the storm drain system for 80% of the jurisdiction's streets. Regular *[specify stormwater program's frequency]* catch basin cleaning is being implemented to remove sediment from the storm drain system.	Track the amount of materials collected as a part of the street sweeping program. Track the amount of material collected as a part of the catch basin cleaning program. Review maintenance records to determine the frequency with which these activities are being conducted a
Conduct field observations for illicit discharges and document/report evidence of non-stormwater discharges or illegal dumping	How many illicit discharges involve sediment? Are there recurring sources that can be addressed through education and outreach?	Reduce number of illicit discharges involving sediment by 5% each year.	Track IDDE results.

This page intentionally left blank

Trash

This fact sheet has been developed to assist stormwater program managers in understanding why this constituent can be problematic in stormwater and urban runoff, what the potential sources are, and how effectiveness assessment goals and metrics can be established to assist program managers in answering specific management questions in order to adaptively manage their programs.

The approach and methods described herein provide a "toolbox" for stormwater program managers so that they can select the program assessment methods and metrics that are most meaningful to their overall stormwater program.

INTRODUCTION

The term "trash" primarily refers to anthropogenic waste materials, including, but not limited to, convenience food, beverage, and other product packages or containers constructed of steel, aluminum, glass, paper, plastic, and other natural and synthetic materials. When improperly discarded, trash may adversely affect the environment, economy, and/or human health and safety. For example, trash may be ingested by or entangle organisms, alter a sensitive ecosystem, necessitate costly removal and disposal procedures, injure people, and/or pose serious health risks. The extent of such impacts is determined, in part, by the type of trash and where it settles in the environment.

Plastics comprise a significant portion of both existing aquatic debris and the nation's current trash output. Durable and lightweight, plastics can travel significant distances, accumulate in or near waterbodies, and persist in the environment almost indefinitely, all while breaking into smaller and smaller pieces. Coincidentally, the trash of most concern to water quality tends to be small, buoyant, and persistent.[1] Buoyant items tend to be more harmful than settleable

Each stormwater program may also wish to refer to the following source- and activity-specific profiles for additional, example program activities, management questions, goals, and metrics that may apply to this program element:

- ✓ Construction
- ✓ Industrial & Commercial
- ✓ Municipal Operations

[1] USEPA (2002) Assessing and Monitoring Floatable Debris. In: Office of Wetlands, Oceans, and Watersheds; Oceans and Coastal Protection Division. EPA-842-B-02-002. August.

items, due to their ability to be transported throughout a waterbody and ultimately to the marine environment.[2] Additionally, small items are difficult to capture and remove.

SOURCES OF TRASH

Identification of trash sources is important and necessary for regulating, controlling, and preventing the improper release of trash. However, determining exactly from where trash originates can be challenging, since trash can travel long distances before being deposited on shorelines or settling to the bed of a waterbody. Trash that ends up in an aquatic environment is often the result of deliberate or accidental actions by people, whether on land or over water. Even trash that has been deposited into waste receptacles may not be safely contained because stormwater flows and wind action can transport such items to nearby waterbodies. This is especially problematic in urban areas, where population density is high, littering is frequent, and paved surfaces are common.

Possible sources of trash include individuals, industrial and commercial activities, construction, and natural events (**Table 1**). Additionally, municipalities are responsible for capturing trash that is dropped or discarded by individuals. Without sufficient mechanisms for capturing trash, municipal separate storm sewer systems (MS4s) may convey trash into nearby waterbodies or the ocean.

[2] Surface Water Ambient Monitoring Program (2007). A Rapid Trash Assessment Method Applied to Waters of the San Francisco Bay Region: Trash Measurement in Streams. April.

Trash

Table 1. Potential Sources of Trash

Sources and Activities
Construction Sources
Construction and demolition sites
Residential Sources
Littering or dumping
Open or overflowing waste management bins
Special events
Homeless encampments
Illegal dumping
Industrial/Commercial Sources
Production, transport, maintenance, cleanup, and disposal activities
Open or overflowing waste management bins
Municipal Sources
Littering or dumping
Open or overflowing waste management bins
Special events
Homeless encampments
Illegal dumping

Examples of common trash types, categorized by probable sources, are provided in **Table 2**.

Trash

Table 2. Examples of Trash Types[3]

Sources and Types
Construction Sources
Bricks
Concrete
Insulation
Rebar
Wood debris
Garbage
• Paper/cardboard
• Containers
• Utensils
• Organics
Residential Sources
Plastic
• Bags and wrappers
• Containers
• Utensils
Glass
Paper/cardboard
Metal
Cigarette butts
Medical and personal waste
Syringes
Industrial/Commercial Sources
Plastic
• Pre-production plastic pellets
• Other plastics
Metal parts
Synthetic rubber, cloth, or fabric
Chemical containers
Garbage
• Paper/cardboard
• Containers
• Utensils
• Organics

[3] This list is not intended to be comprehensive.

Trash

MANAGEMENT QUESTIONS, GOAL SETTING, AND METRIC IDENTIFICATION

As the stormwater program is developed, it is important that the program manager considers how the program will be able to answer critical management questions (both environmental and programmatic), and incorporate measureable, achievable goals and corresponding metrics that are consistent with the program's priorities. Example management questions and the corresponding goals and metrics specific to trash are provided below. However, each stormwater program manager will need to decide what management questions and goals are most applicable to and in alignment with their program's priorities.

Example Trash-Related Management Questions and Goals

The management questions identified below are examples of the types of questions that a program can be designed to assist in answering. The questions are designed to assist program managers in adaptively managing their programs so that they can prioritize their resources.

Outcome Level	Management Question
6	Are impacted waterways meeting the TMDL targets for trash as specified in the applicable TMDL(s)?
5, 6	Are the urban stormwater dischargers a significant source of trash to the receiving waters? Are there other sources that are major contributors?
5	Are the Permittees meeting the load allocations for trash as specified in the applicable TMDL(s)?
2 to 4	Are the Permittees effectively implementing BMPs that target and/or prevent trash?

Table 3 provides example management questions, goals and metrics for outcome levels 2-4.

Trash

Table 3. Example Program Activities, Management Questions, Goals, and Metrics

Program Activity	Management Question	Goal/Metric[4]	Data/Information to be Collected
Construction Operations			
Inspect sites with the potential to contribute trash.	Are construction sites that could generate trash aware of the BMPs that they should be implementing on site, and are they implemented and maintained?	90-100% of the sites are aware of the need to implement the necessary BMPs and are doing so. For example, trash should be properly managed and contained within appropriate, covered waste containers.	Track inspection results and/or conduct surveys.
Residential Operations			
Develop educational materials with information regarding trash. Update the website. Provide these materials at outreach events, etc.	Is the general public aware of the need to properly dispose of trash?	Based on survey results, 20-25% of the residents are aware of the need to properly dispose of trash. Based on survey results, 20-25% of the residents are reporting that they properly dispose of trash. The amount of materials collected as a part of the creek cleanups is decreasing.	Identify the source(s) of information for the residents (public service announcements (PSAs), brochures, community events, etc.) Track how much trash/debris was collectively removed from the local waterways as a part of stream cleanup events. Itemize the types of materials collected.
Industrial/Commercial Operations			
Inspect facilities with the potential to contribute trash.	Are industrial and commercial facilities that could generate trash aware of the BMPs that they should be implementing on site, and are they implemented and maintained?	90-100% of the facilities are aware of the need to implement the necessary BMPs and are doing so. For example, trash should be properly managed and contained within appropriate, covered waste containers.	Track inspection results and/or conduct surveys.

[4] It should be recognized that goals and metrics may be limited to TMDL requirements.

Trash

Program Activity	Management Question	Goal/Metric[4]	Data/Information to be Collected
Municipal Operations			
Inspect facilities with the potential to contribute trash.	Are the municipal facilities that could generate trash aware of the BMPs that they should be implementing on site, and are they implemented and maintained?	90-100% of the facilities are aware of the need to implement the necessary BMPs and are doing so.	Track inspection results and/or conduct surveys. Conduct audits for contracted services
Implement a street sweeping and catch basin cleaning program.	How much material is removed in the street sweeping program? How much material is removed in the catch basin cleaning program?	Regular *[specify stormwater program's frequency]* street sweeping is being implemented to remove trash from the storm drain system for 80% of the jurisdiction's streets. Regular *[specify stormwater program's frequency]* catch basin cleaning is being implemented to remove trash from the storm drain system.	Track the amount of materials collected as a part of the street sweeping program. Track the amount of material collected as a part of the catch basin cleaning program.