California Stormwater Quality Association
An Introduction to Stormwater Program Effectiveness Assessment

A. Introduction

This paper introduces and discusses key concepts and provides a standardized terminology related to the development of a comprehensive framework for assessing the effectiveness of stormwater management programs. It briefly defines and categorizes potential outcomes, measures, and methods to be used in conducting assessments, and provides examples of how several programs are already utilizing these tools to assess their effectiveness. It also discusses the current needs of stormwater program managers with respect to program assessment. The issues addressed in this paper will form the basis for more detailed guidance on effectiveness assessment that will be developed by the California Stormwater Quality Association (CASQA) Effectiveness Assessment Subcommittee during 2005-06.

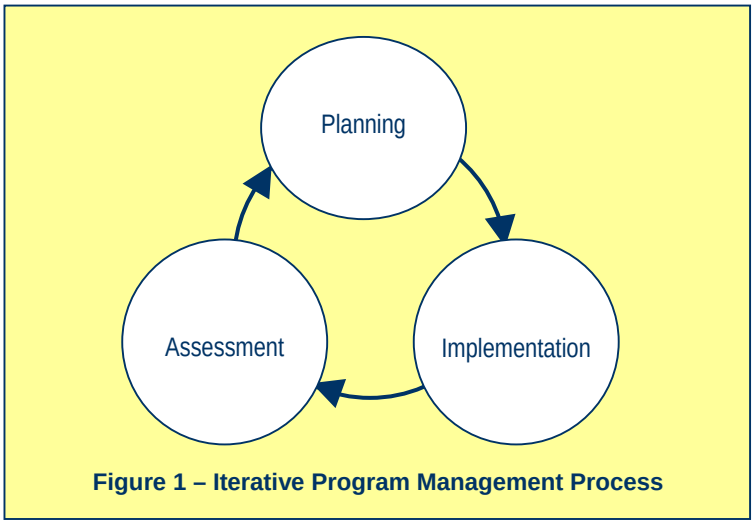

Figure 1 – Iterative Program Management Process

Effectiveness assessment is a fundamental and necessary component of developing and implementing successful programs. It begins with the establishment of goals, objectives, and desired outcomes during program planning, and continues throughout subsequent implementation and review stages. A well-executed assessment element can provide managers the feedback necessary to determine whether their programs are achieving intended outcomes (complying with permit requirements, increasing public awareness, changing behaviors, etc.), and ultimately whether continued implementation will result in water quality and/or habitat improvement. Figure 1 illustrates an idealized model in which each of three management elements continuously informs the next in an iterative cycle of feedback and improvement. While this model is useful for illustration, it bears emphasis that the most successful programs are those that address assessment during all stages of program activity, especially planning.

Municipal stormwater management programs in California are broadly focused on reducing pollutants in stormwater and non-stormwater discharges to the maximum extent practicable (MEP), and on ensuring that these discharges do not cause or contribute to violations of applicable water quality standards. To achieve these objectives, they employ a variety of strategies to bring about the implementation of best management practices (BMPs) in a manner that will most effectively and cost-efficiently achieve regulatory compliance and protect the beneficial uses of receiving waters. To ensure that programs are measurable and effective, most municipal separate storm sewer system (MS4) National Pollution Discharge Elimination System (NPDES) stormwater permits contain specific requirements for periodic assessment. Most programs report on effectiveness as part of their annual report, but effectiveness assessment should be integral to the program and an ongoing process used throughout the year.

Stormwater managers currently find themselves at an important crossroads. Faced with a continually increasing need to demonstrate measurability and accountability, they must have a reasonable expectation of success before committing resources toward specific activities. Therefore, good effectiveness assessment tools are critical. Managers have historically relied on a combination of programmatic or implementation evaluations and direct water quality evaluations to determine whether their efforts are effective in achieving intended outcomes. In addition, some program managers are still in need of basic information on useful assessment methods.

Developing consensus on how to continue improving these approaches and providing guidance on selecting

and using applicable assessment methods must remain priorities. More importantly, a critical need has emerged to work toward integration of assessment methods so that linkages between program activities and measurable changes in water quality can be definitively established and continually refined. A well-conceived integrated approach for assessing the effectiveness of stormwater programs is necessary to ensure their measurability and success in the future.

B. What is Effectiveness Assessment?

Clarifying what is meant by effectiveness assessment, as well as the factors that need to be considered when assessing programs, is an important first step toward developing useful methods and approaches.

Effectiveness Assessment is the process that managers use to evaluate whether their programs are resulting in desired outcomes, and whether these outcomes are being achieved efficiently and cost-effectively. The specific approach to be used in assessing effectiveness will depend on a variety of factors including the type of program element or activity being evaluated and the stage of program development (i.e., planning, implementation, completion). However, as noted earlier, a comprehensive effectiveness assessment strategy should evaluate program implementation and water quality, and seek to find the relationship between the two (Figure 2).

Implementation Assessment provides managers feedback on the effectiveness of their programs in achieving targeted objectives. This type of assessment is essential in determining whether priority sources of pollution are being effectively addressed. Implementation assessment may include any of three levels of analysis: the overall program, the elements that comprise the program (construction sources, municipal sources, etc.), or the specific activities that are conducted within these program elements. Figure 3 shows these levels and provides examples to illustrate their relationship. While assessment strategies most commonly focus on specific activities such as inspections, street sweeping, debris collection, or implementation of best management practices, a comprehensive strategy should also encompass individual program elements and the overall program. Depending on the intended objectives at each level, assessment approaches will necessarily vary. These may range in complexity from simple activities such as verifying the completion of activities to more sophisticated techniques such as assessing the probable or actual locations of these activities and the significance of their spatial distribution.

Water Quality Assessment is the use of sampling data and related information to evaluate the condition of non-stormwater or stormwater discharges, and the water bodies that receive these discharges. This can include a variety of chemical, biological, and physical parameters or outcomes. In instances where water quality assessment is used to draw conclusions about overall program effectiveness, results are usually very general and require extended periods of analysis.

Integrated Assessment is the process of evaluating whether program implementation is resulting in the protection or improvement of water quality. In this process, relationships between program activities and water quality improvements are explored and refined. Because of the number and variety of BMPs and control programs being implemented at any given time, and because many factors external to stormwater programs affect water quality, establishing these relationships is difficult. Efforts to date have included speculative or hypothetical exercises aimed at better understanding likely program outcomes and potential

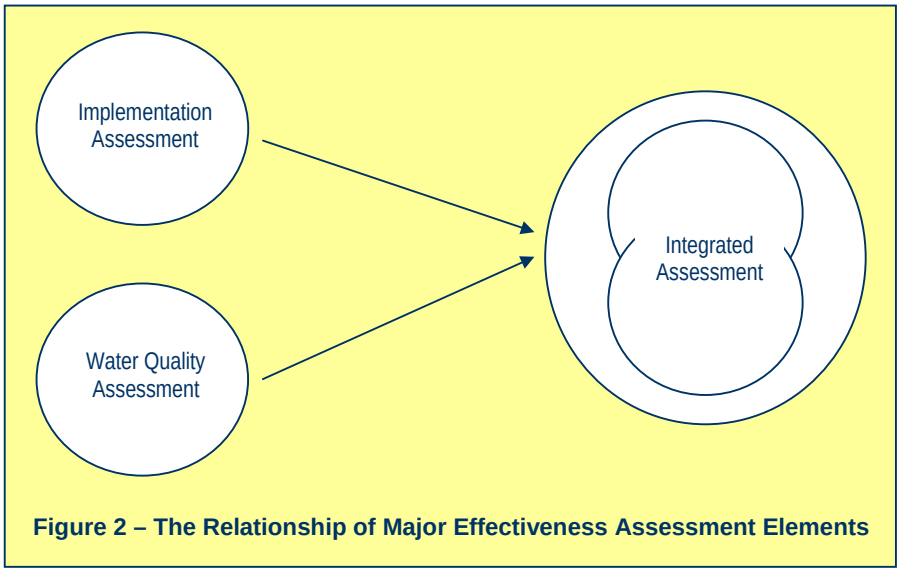

Figure 2 – The Relationship of Major Effectiveness Assessment Elements

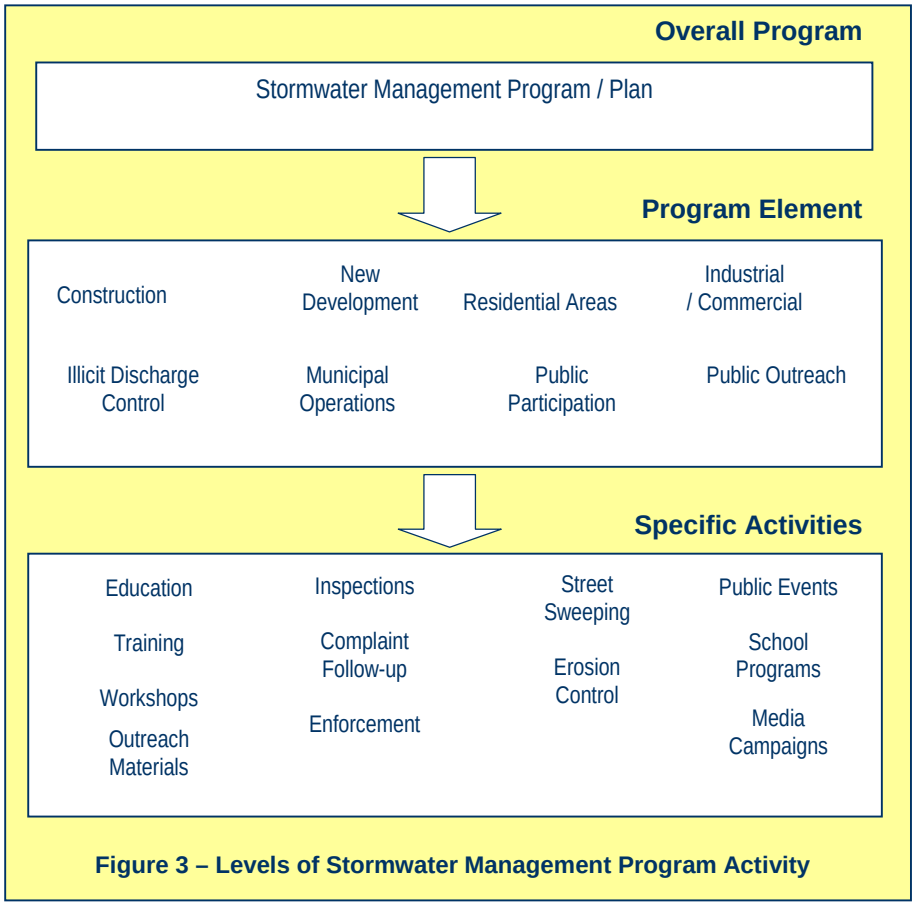

Figure 3 – Levels of Stormwater Management Program Activity

relationships to water quality. Quantitative "cause and effect" relationships will increasingly be sought in the future. This is a critical linkage because implementation assessment is, in many cases, simpler and less costly than water quality assessment. In addition, the time frame needed to see measurable results is shorter for implementation assessments. Over time, correlating water quality improvement to programmatic results will assist stormwater managers in identifying the most expedient and cost-effective approaches to planning and assessing their programs.

C. Types of Assessment Outcomes

Stormwater managers currently use a number of different approaches to draw conclusions about the effectiveness of their activities and programs. This involves the evaluation and measurement of various types of programmatic and environmental outcomes.

Outcomes are the results of an activity, program element, or overall program. The discussion below characterizes the possible types of outcomes in terms of six levels. As illustrated in Figure 4, these levels represent a gradation from activity-based to water quality-based outcomes. Though each level has value in informing management decisions, it bears emphasis that not all are necessary or possible in every instance. For example, in many instances Level 2 or 3 Outcomes will be sufficient for evaluating the effectiveness of implementation of outreach or training programs.

The pyramidal structure of Figure 4 is intended to illustrate the progression of each successive step toward the ultimate goal of environmental improvement. In general, Levels 1 to 3 can be considered Implementation Outcomes, Levels 5 and 6 Water Quality Outcomes and Level 4 a combination of the two types. While an important objective of the effectiveness assessment process is to establish relationships between Levels 1 and 6, this often becomes increasingly difficult as one moves toward higher levels of assessment. It should also be noted that, while these levels are presented in sequence, efforts to address each are independent and ongoing. For example, increases in awareness and knowledge may continue to be assessed even as strategies are broadened to include load reduction estimates.

Level 1: Compliance with Activity-based Permit Requirements. Many specific activities are either prescribed by or established under stormwater NPDES permits. Examples include conducting education to encourage BMP implementation, inspecting facilities, and enforcing discharge prohibitions. The most basic means of assessing effectiveness is to determine compliance with activity-based permit requirements. Level 1 Outcomes may therefore take the form of a simple yes/no answer. They may also be quantified, counted, or tracked over time to demonstrate effort or progress. Level 1 Outcomes are assumed to be beneficial to water quality, but often lack a factual basis to support these assumptions. Their fundamental characteristic is that they reflect program activity only; they are not indicators of the effect of implementation on people or the environment.

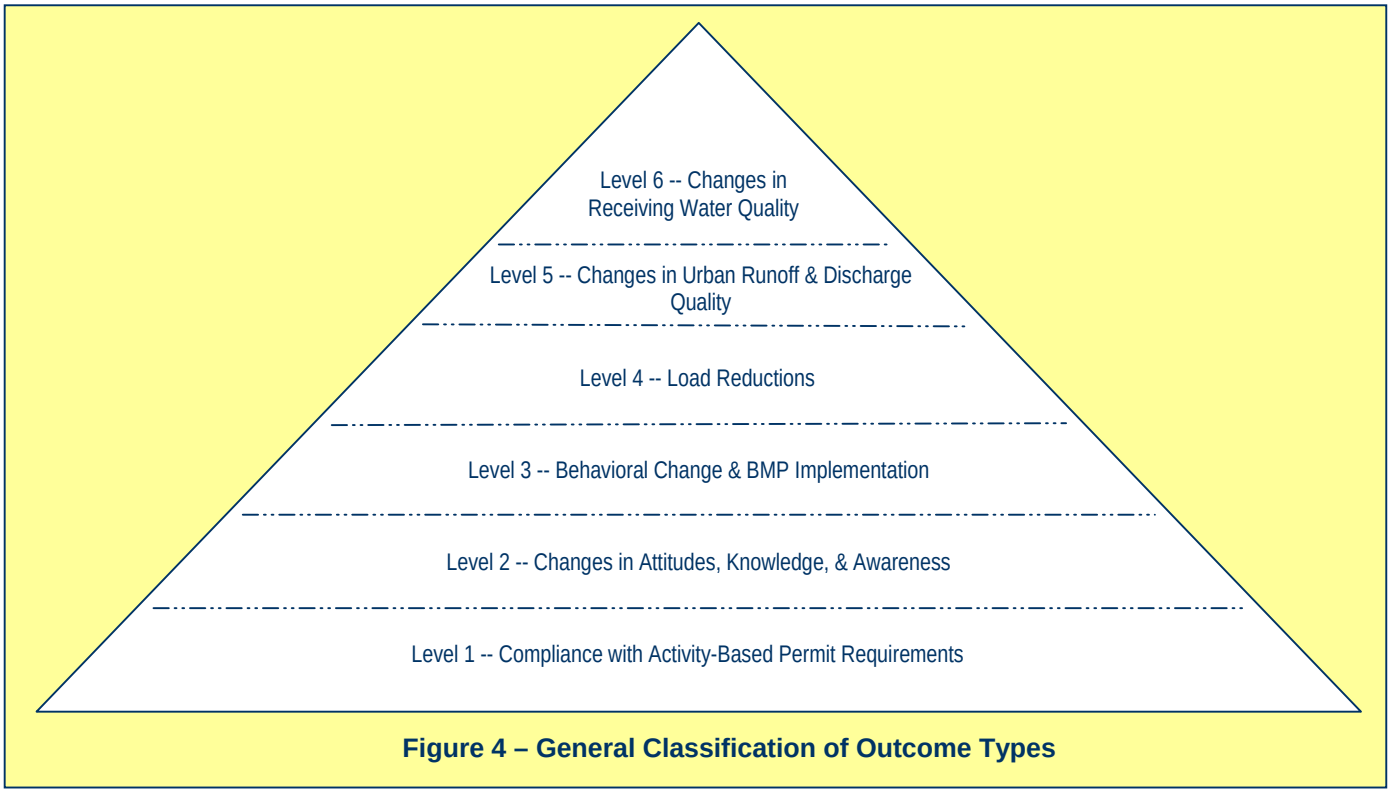

Figure 4 – General Classification of Outcome Types

-- Assessing Level 1 Outcomes -- Program Activity

Basic measurements of program activity are a crucial part of the overall assessment process. Level 1 Outcomes provide managers direct feedback on how well implementation is progressing and whether targeted goals and objectives are being met. Typical examples of targeted outcomes include the following:

- How many trainings or outreach events were conducted?
- How many people were reached?
- How many inspections were conducted?
- Were minimum inspection frequencies met?
- Did the number of inspections increase from previous years?
- How many illicit discharges were identified?
- How many were eliminated?
- Are illicit discharges increasing or decreasing over time?

Level 2: Changes in Attitudes, Knowledge, & Awareness. An important goal of stormwater programs is to increase the level of knowledge and awareness among target audiences such as residents, businesses, and municipal employees. Similar to the discussion above, augmenting awareness and changing attitudes about stormwater pollution and BMPs is generally assumed to be beneficial to the environment because increased awareness and attitudinal changes provide the basis for behavioral change. Measuring Level 2 Outcomes is a useful way of gauging whether educational efforts are progressing toward these changes.

Various methods and tools, both quantitative and qualitative, are currently utilized to measure changes in knowledge and awareness. These generally take the form of surveys and quizzes. Changes may also be inferred by tracking levels of public involvement (e.g., through complaints or requests for information received via stormwater hotlines). However, there may be limitations to using this method because many different factors influence levels of public involvement.

-- Assessing Level 2 Outcomes --
Attitudes, Knowledge, & Awareness

Understanding what people know and care about is the first step in developing effective outreach programs. Two programs in Northern California recently utilized surveys as a tool for refining and evaluating their outreach efforts.

Davis Healthy Gardens Program – During 2000, the City of Davis conducted phone and mail surveys to evaluate general levels of awareness and to help target potential behavioral changes for pesticide use and disposal. The City was able to use this information to determine if the basic program message was being effectively communicated, and which outreach methods and locations worked best for creating awareness and for changing behavior.

Woodland Oil and Grease Reduction Project – In 2000, the City of Woodland developed an outreach program to encourage the proper disposal of used cooking oil by residents. The primary means of assessing program effectiveness was the use of intercept surveys. These surveys provided vital information on whether outreach messages were understood, whether identifiable factors influenced the likelihood of improper disposal (e.g., family size, high density vs. low density neighborhoods, renting vs. owning, cooking habits, etc.), and ultimately on which outreach approaches worked the best (e.g., use of more than one language for outreach).

Level 3: Behavioral Change & BMP Implementation. Building on increases in knowledge and awareness, a key focus of management programs is to effect changes in behavior. Level 3 Outcomes measure the effectiveness of programs in motivating target audiences to change their behaviors and implement appropriate BMPs. Methods used to measure behavioral changes include those described above for Level 2 Outcomes, as well as direct observation via site visits and reporting by dischargers or third parties.

Level 4: Load Reductions. Most activities implemented through stormwater programs are intended to reduce the loading of pollutants from targeted sources. Load reductions should in turn result in improvements to discharge and receiving water quality. Load reductions quantify changes in the amounts of pollutants associated with specific sources before and after a BMP or other control strategy is employed.

-- Assessing Level 3 Outcomes --
Behavioral Change & BMP Implementation

Managers are increasingly utilizing a variety of methods to determine whether program implementation is resulting in targeted behavioral changes such as decreases in discharges and increased BMP implementation.

ACCWP Evaluation of Effectiveness Business Inspections – In 2000, the Alameda Countywide Clean Water Program (ACCWP) completed a comprehensive assessment of its facility inspection program using data collected between 1996 and 1999. Data were assessed to determine how well program objectives were being met, whether program implementation was resulting in corresponding behavioral changes, and to provide recommendations for prioritizing facilities and improving inspections. At the end of the four-year study, ACCWP staff was able to determine that non-stormwater discharges had decreased and BMP implementation increased at regulated businesses.

San Francisco Mercury Reduction Project – To evaluate the effectiveness of efforts to educate the public regarding the environmental impact of improperly disposing of mercury fever thermometers, San Francisco Water Pollution Prevention Program staff conducted intercept surveys and tracked the number of thermometers turned in at collection events. A random-digit-dial phone survey was also used to evaluate overall program effectiveness in discouraging the use of thermometers. A separate element of the project utilized site visits to assess whether outreach to dentists is facilitating proper amalgam waste management. This project provides an excellent example of how a variety of simple, low cost approaches to evaluating behavioral change can be used to evaluate the effectiveness of specific activities.

They are most valuable for making broad comparisons or for helping managers to distinguish where resource allocations are likely to be most useful. Developing a baseline of data and information to support load reduction estimates is key to their application. In the future, it is hoped that the development of such a baseline, as well as approaches for incorporating direct measurement, will enable a significant expansion of the use of load reduction estimates.

Level 5: Changes in Urban Runoff & Discharge Quality. As discussed above, a primary focus of stormwater management programs is to reduce pollutants in stormwater and non-stormwater discharges to the maximum extent practicable, and to

-- Assessing Level 4 Outcomes --
Pollutant Load Reductions

Load reduction estimates provide an important focal point for determining whether program implementation is achieving, or likely to achieve, meaningful outcomes. In recent years, many jurisdictions have increasingly used such methods to estimate the benefits of implementation and to prioritize program spending.

ACCWP Street Sweeping Assessment – As part of their annual reporting process, Alameda Countywide Clean Water Program (ACCWP) copermittees track the amount of street sweeping waste collected. ACCWP combines this information with PCB and mercury concentrations measured in sediment samples taken from inlets, catch basins, and pump stations to estimate the loads of these compounds diverted from the storm drain system as a result of street sweeping. Results allow the identification of potential improvements to street sweeping operations (e.g., to determine whether load diversions could be increased relative to costs), as well as comparison to results from storm drain cleaning and desilting operations.

County of San Diego Construction Activities Assessment – Since FY 2002-03, the County of San Diego has estimated load reductions resulting from BMP implementation at construction sites. Because of the extremely large number of permitted sites open throughout the year, the County determined that the collection and analysis of detailed site-specific data and information would generally be infeasible. Instead, the County employed a less direct approach of estimating levels of site protection and projecting loading rates before and after BMP implementation. In other words, reductions were calculated as the difference between completely unprotected and completely protected sites. This analysis relied heavily on the use of literature values and assumptions about site conditions.

-- Assessing Level 5 Outcomes --
Urban Runoff & Discharge Quality

Measuring changes in the quality of urban runoff and conveyance system discharges (before the water reaches receiving waters) is possibly the most direct expression of program effectiveness.

Davis Healthy Gardens Outreach Program – Pesticide levels in runoff from a residential outfall decreased over the same time frame that the Healthy Gardens Outreach Program was implemented in Davis, California. In general, spatial and temporal variability in pollutant concentrations in stormwater make it difficult to establish such cause and effect relationships. In this example, it was possible to isolate a residential area in Davis that had been targeted by the outreach program. This is not always the case. Outfalls typically drain large urbanized areas and the effects of activities and programs implemented are generally not seen in discharge quality measurements.

Ventura Countywide Stormwater Quality Management Program trend analysis - Ventura County has been able to assess long term impacts based on trend analysis. In 2003, all runoff monitoring data collected since 1993 was used to evaluate trends in water quality. While some organics and metals appeared problematic at sampling locations throughout the watershed, the number of detected organics had decreased significantly since the Program was implemented. More importantly, an analysis of Pollutants of Concern (POCs) showed that Sediment/Total Suspended Solids (TSS), initially identified as a POC in 1998, was no longer of concern. This improvement was attributed to the efforts of the copermittees to decrease sediment contributions from construction sites to stormwater runoff. In addition, Mercury and PAHs were no longer top-ranked POCs.

ensure that these discharges do not cause or contribute to violations of water quality standards in receiving waters. In many respects, Level 5 Outcomes are the most direct expression of successful program implementation. They may be measured as reductions in one or more specific pollutants, and may reflect effectiveness at a variety of scales ranging from site-specific to programmatic.

Level 6: Changes in Receiving Water Quality. The ultimate objective of stormwater management programs is the protection of water bodies receiving discharges from MS4s. Changes to receiving water and environmental quality may be expressed through a variety of outcomes such as compliance with regulatory benchmarks, protection of biological integrity, and beneficial use attainment. Regardless of the outcomes targeted, it is useful to keep in mind that receiving water quality often reflects more than the quality of stormwater discharges alone.

D. Assessment Measures and Methods

Once the desired outcomes of program implementation have been clearly defined, specific measures and methods can be developed for evaluating success in achieving them. **Assessment Measures** are established to determine whether or how successfully a

-- Assessing Level 6 Outcomes --
Receiving Water Quality

Improvements in environmental and water quality represent the ultimate goal of stormwater programs. Observable changes in receiving waters may require long time frames to be measurable.

Lead reductions in gasoline – Lead levels in gasoline were reduced by greater than 90% in the 1980s. This drastic source control action cascaded through the environment as evidenced by an approximate reduction of 90% in lead levels in air by the 1990s. Similarly, there has been an approximate 90% reduction in lead–related lung diseases and approximate 90% reduction in lead levels in runoff. As is often the case with environmental improvements resulting from source control, the time frame over which this was observed was several years.

Diazinon phase-out – In the mid-1990's aquatic toxicity in San Francisco Bay Urban Creeks was substantial and linked to relatively high concentrations of the organophosphate pesticide diazinon. Consequently, these creeks were listed as impaired on the 303(d) list as impaired. To address this impairment, wastewater and stormwater programs throughout Northern California conducted extensive outreach and education programs regarding the impacts of diazinon and alternative pest control methods. In addition, the wastewater and stormwater programs worked with EPA, Department of Pesticide Regulation, and the diazinon manufacturers to identify solutions to the impairment. In 2000, the USEPA announced the phase out of diazinon products and since then, the amount of reported diazinon applications has decreased substantially. In turn, aquatic toxicity and diazinon concentration in urban creeks have decreased dramatically.

programmatic or water quality outcome has been achieved. They 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 multiple measures. As discussed in Section B above, assessment measures can be focused on implementation or water quality assessment.

They should be selected based on their ability to provide useful information to the program manager. Attributes of a good assessment measure include:

- Measurability (statistically measurable on a frequent basis)
- Relevance (significant, demonstrable relation to strategy and objectives)
- Reliability (easily documented and reproducible)
- Availability (based upon data obtainable at reasonable cost)
- Scientific Validity (based on sound science)
- Replicability (capable of being regularly updated)
- Appropriately Focused (ideally measures outcomes, not inputs or outputs)

As noted above in the discussion of outcome levels, some effectiveness measures are based on assumptions and will have significant uncertainties associated with them. Other measures may be more statistically significant, allowing assessment of central tendencies (e.g., mean or median values) and data variability (e.g., standard deviations). Clearly, measuring the impact of stormwater programs is much easier and more meaningful if baseline levels can be established. It is therefore useful to evaluate available data at each outcome level prior to implementing a program (e.g., awareness levels before an outreach campaign is conducted, water quality before a series of BMPs is implemented). Example assessment measures are listed in Table 1 and are categorized by assessment method.

Assessment Methods are the specific activities, actions, or processes used to obtain and evaluate assessment data or information. Depending on the particular outcome in question, numerous assessment methods may be possible. Reasons for selecting a particular method include cost, ease of use, need for statistical rigor, applicability, and clarity in communicating progress to the general public. For example, headline indicators are objective measurements that reflect in simple terms how a stormwater program is progressing towards its goals. They are based on fundamental factors determining environmental quality and how easily they are understood. Assessment methods can be broadly categorized according to the following types of activity:

- **Confirmation** consists of documenting whether an activity or task has been completed. It is always expressed as a positive or negative outcome (i.e., yes or no), and should be used almost exclusively at Outcome Level 1.

Table 1 -- Examples of Assessment Methods and Measures by Outcome Level

	Outcome Level	Assessment Method Type	Assessment Measure	Examples
1	Activity-based	Confirmation	o Task completion (Y/N)	o Completed update of source inventory
		Tabulation	o Implementation (# or %) o Change	o Number of inspections completed o Increase since 2001
2	Attitudes, Knowledge, & Awareness	Survey	o Knowledge	o Knowledge of storm drain vs. sanitary sewer
		Tabulation	o Change o Action o Change	o Increase in awareness since last survey o Number of hotline calls/ website hits o Increase over last year
3	Behavioral Change & BMP Implementation	Inspection	o Implementation (# or %) o Change	o Installation of berms around trash areas o Increase since beginning of program
		Reporting (discharger)	o Implementation (# or %) o Change	o Installation of storm drain inserts o % increase
		Reporting (3rd party)	o Implementation / non-compliance (# or %) o Change	o No. of Complaints reported o Decrease since beginning of program
		Survey	o Implementation (# or %) o Change	o No. of people picking up pet waste o Increase over last year
4	Load Reduction	Quantification	o Loading o Change	o Copper released from brake pads o Decrease since 1996
		Monitoring (Sampling)	o Loading o Change	o Diazinon loading from lawns o Decrease since 2002
5	Urban Runoff & Discharge Quality	Monitoring (Sampling)	o Benchmark o Loading o Change o Concentration o Change	o Comparison of Cu to Water Quality Objective o Phosphorous loading to MS4 o Increase since 1993 o TSS levels in runoff o Increase since 1995
6	Receiving Water Quality	Monitoring (Sampling)	o Benchmark o Concentration	o Comparison of Zn to Water Quality Standard o Nitrate concentration in Rainbow Creek
		Monitoring (Observation)	o Biological condition o Physical habitat o Biological condition o Physical habitat	o Stream biodiversity o Scouring of Stream bank o Loss of riparian canopy o Erosion of stream bank

- **Tabulation** consists of simple accounting, and can be expressed in both absolute (e.g., the number of people participating in an event) and relative terms (e.g., percent increase in pounds of household hazardous waste collected). Tabulation is an extremely common and useful method for assessing activities at Outcome Levels 1 through 3.

- **Surveying** encompasses a variety of methods (e.g., random-digit-dial phone surveys, intercept surveys in a shopping mall) designed to discern the knowledge, attitudes, awareness, or behaviors of a specific population (residents, schoolchildren, automotive enthusiasts, etc.). Surveys vary greatly in the degree to which they are quantitative and statistically valid. Surveys are applicable for Outcome Levels 2 and 3.

- **Quantification** applies primarily to Outcome Levels 4-6 and refers to efforts to quantify reductions in loading or runoff discharges, or to improvements in environmental quality. Often,

particularly at Outcome Level 4, quantification requires the use of estimates that are based on various untested assumptions. Estimation will remain a highly utilized method until many of these assumptions can be verified or refined.

- **Inspections or Site Visits** include any method utilized to directly observe or assess practices used by a targeted audience. They may be regulatory or conducted as part of an information gathering exercise or educational outreach effort. Inspections may be proactive or reactive. Proactive, or scheduled, inspections are most commonly conducted to assess practices at commercial or industrial facilities, construction sites, and municipal facilities. In addition to each of these source types, reactive, or complaint-initiated, inspections are also conducted at residences in addition to commercial and industrial sites.

- **Reporting** is the receipt of implementation, compliance, or other assessment-related information generated by other parties. This may include discharger reporting or third party audits.

- **Monitoring** is the measurement of environmental or water quality conditions, including changes over time. Monitoring methods apply exclusively at Outcome Levels 4, 5, and 6. Monitoring is accomplished through sampling or through observation. Sampling involves collecting water, sediment, or biota in order to directly measure pollutant levels in the environment. Observation involves visual surveys of habitat condition and the use of remote sensing to assess environmental conditions such as vegetative cover or imperviousness.

E. Effectiveness Assessment Needs and Future Directions

The goals of the CASQA Effectiveness Assessment Subcommittee are to continue developing consensus on general approaches, and to further the development of specific tools that will improve the state-of-the-art in this field. Stormwater program managers need guidance on which assessment methods are effective and how to use them to ensure that useful information will be obtained. To evaluate managers' needs, a survey of CASQA members was conducted. The results of this survey are found in Attachment A.

Survey findings include the following:

- The most common reason stormwater management programs conduct effectiveness assessments is to demonstrate compliance with NPDES permit requirements, but several programs reported using assessment results to plan program activities.

- Although direct measures of effectiveness are included in most current stormwater NPDES permits, indirect measurements are used to a much greater extent by stormwater management programs. In particular, programs are most likely to measure the implementation of program elements rather than the impacts resulting from them.

- Survey results indicate that guidance is needed for all program elements and outcome levels. However, respondents ranked post-construction stormwater runoff, water quality monitoring, and watershed assessment as the program areas with the greatest needs. Results also indicated that specific guidance is needed on methods to measure pollutant load reductions, changes in public knowledge and awareness, stormwater discharge quality, and behavior change and BMP implementation.

As noted, there are certain levels at which evaluation is difficult due to resource limitations or the complexity of the measurement needs. Certain evaluation measures, particularly those associated with monitoring or measurement over long time frames, would benefit from development and research conducted on a regional or statewide level. Identification of these evaluation measures, approaches to developing such measures so they are more widely useful, and identification of funding mechanisms to facilitate their development, may be appropriate tasks for an organization such as CASQA.

Process and methods for conducting integrated assessment need to be established. As noted above, assessment methods at the higher outcome levels (i.e., levels 4-6) may be costly and require longer timeframes. The cost-effectiveness of assessment is a critical factor. Assessment tools that are more costly

than the program or activity being evaluated are not practical. Therefore, efforts to pool resources and to develop low cost tools are needed. It may be possible to identify correlations between effective implementation and water quality improvement. This would allow program managers to use implementation assessments (which are simpler and less costly) as indicators of water quality and environmental improvement. Approaches to more definitively linking stormwater program implementation to resulting environmental improvements may also benefit from a regional or statewide approach making this another potential future task for CASQA.

Future efforts should include the following:

- Development of a guidance document describing the process for identifying effectiveness measures and incorporating these measures into both existing and new stormwater programs. Assessment measures for all outcome levels should be included.

- Identification of cost-effective approaches to assessment measurement. One of the critical roles of assessment measurement is to assist program managers in optimizing their resources when developing successful programs. Clearly, low-cost approaches to effectiveness assessment are needed to accomplish this.

- Development of the tools needed to facilitate water quality assessment. Most stormwater programs are required to directly measure improvements in water quality. However, this type of assessment is conducted to a far lesser extent than implementation assessment, often due to a lack of readily available and understandable methods.

- Creation of opportunities for stormwater programs to pool their resources to develop the tools, data, and information needed to assess program costs effectively. Specifically, statewide efforts should be initiated to develop the methods needed to correlate water quality and environmental assessment with implementation assessments.