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Caltrans Comprehensive Protocols Guidance Manual

CONTAINS:

Stormwater Quality Monitoring Protocols
Particle/Sediment Monitoring Protocols
Gross Solids Monitoring Protocols
Toxicity Monitoring Protocols

Caltrans Data Reporting Protocols

CTSW-RT-03-105.51.42

California Department of Transportation

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Caltrans Monitoring Protocols: Stormwater Quality Monitoring

JULY 2000

GUIDANCE MANUAL: Stormwater Quality Monitoring Protocols

(Third Edition)

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FOREWORD

This manual was prepared by the Office of Environmental Engineering, California Department of Transportation (Caltrans). The manual establishes uniform policies and procedures to support the stormwater monitoring functions of the Department. It is neither intended as, nor does it establish, a legal standard for those functions. The policies established herein are for the information and guidance of the officers and employees of the Department and its contractors.

The guidance and instructions published herein are subject to amendment as conditions and experience warrant. The loose-leaf form of this manual was chosen because it facilitates change and expansion. New or amended policies or procedures will be issued as additional or replacement pages in the format of this manual.

Special situations may warrant variation from the published policies and procedures, subject to approval of the Office of Environmental Engineering, or other approval as may be specifically provided for. This manual is not a textbook or a substitute for engineering or technical knowledge, experience or judgement.

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The work was performed by Larry Walker Associates with the assistance and cooperation of various Caltrans, University and contract consultant personnel, who participated in workshops and provided review and commentary on the revisions. Key contributors to the technical review team included Chris Herencia (Caltrans), Masoud Kayhanian (University of California, Davis), Stewart Oakley (California State University, Chico), Adrianne Saboya (Brown and Caldwell Consultants), Bonny Starr (Montgomery Watson), Ed Othmer (LAW Crandall), Lou Regenmorter (Camp Dresser and McKee), and Marty Stevenson and Ken Kronschnabl (Kinnetic Laboratories).

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SECTION 1
INTRODUCTION

This manual presents guidance for Caltrans management, staff, and contractors to use in the planning and implementation of stormwater monitoring programs. The manual is designed and organized to provide step-by-step descriptions of the processes used to plan and implement a successful water quality monitoring program specific to runoff from transportation-related facilities.

The main objective of this manual is to provide consistency in monitoring methods among Caltrans various monitoring programs and projects, as well as consistency in monitoring protocols over time. Such consistency is essential to provide for data comparability, and for ease of data entry in the Caltrans stormwater database. In addition to consistency of monitoring methods, it is essential that monitoring data be collected so as to ensure that the data are accurate and precise. This manual therefore features detailed information on quality assurance and quality control procedures.

The focus of this guidance manual is on monitoring protocols that are used to plan and implement sampling and analysis for chemical and physical constituents, as part of a water quality monitoring program. Supplemental monitoring approaches that can be used to support water quality monitoring, including sediment chemistry monitoring, toxicity testing, use of biological or physical indicators, and visual monitoring are also briefly discussed in Appendix A of this manual.

This guidance manual is specifically prepared to address the monitoring of stormwater runoff from transportation facilities, and provide supporting information for the planning functions of the Caltrans Statewide Storm Water Management Plan (SWMP). The guidance manual is organized into two principal parts:

- **PART I: PREPARING THE MONITORING PLAN**

Part I of the manual is comprised of sections 2 through 6, covering topics relevant to planning a monitoring program, including: developing purpose and objectives, site selection, constituent selection, selection of sampling methods and equipment, and documentation.

- **PART II: IMPLEMENTING THE MONITORING PLAN**

Part II of the manual is comprised of sections 7 thorugh 14, covering topics relevant to implementing a monitoring program, including: equipment installation and maintenance, training, preparation and logistics, sample collection, quality assurance/quality control, laboratory sample preparation and analytical methods, QA/QC data evaluation, and data reporting.

PREPARING THE MONITORING PLAN

SECTION 2
DEVELOP PURPOSE AND OBJECTIVES

In general, Caltrans stormwater monitoring projects are meant to provide data to support the Caltrans stormwater management program, and to comply with various regulatory and legal requirements. The data produced by these monitoring programs must satisfy the immediate goals and objectives of the projects as defined in the Caltrans Stormwater Management Plan (Caltrans, 1999a) and the Caltrans Monitoring and Research Strategy (Caltrans, 2000), and must also be scientifically defensible in a range of other potential applications. Possible applications beyond the specific purposes of the monitoring program (e.g. characterization of discharges or evaluation of BMP performance) include various modeling applications, comparisons to other studies, and assessments of contributions to receiving water loadings.

The planning steps of Caltrans stormwater monitoring programs, as presented in this guidance document, are part of a "systematic planning process" designed to develop appropriate acceptance/performance criteria for data collection and evaluation. [Note: The systematic planning process will be described by USEPA in a soon-to-be drafted manual (expected July 2000), "Guidance on Performance and Acceptance Criteria" (John Warren, USEPA, personal communication).]

The systematic planning process used as the basis for this section is distinct from EPA's "Data Quality Objectives (DQO) Process" (USEPA, 1994). As described by EPA, the "DQO Process" is a specific application of the more general systematic planning process, focused on studies involving a decision-making process in which "environmental data are used to select between two opposing conditions". For Caltrans monitoring projects, the data collection effort is generally not directed at choosing between two alternatives. The planning process described in this section includes relevant ideas from EPA guidance as they apply to the planning and implementation of Caltrans monitoring projects.

For the purposes of this Guidance Manual, "data quality objectives" (DQOs) refer to the set of specific performance and acceptance criteria applied to field and laboratory activities. The DQOs developed for each project establish measures of acceptable performance and data quality for the collected data, and this guidance manual describes procedures by which the data should be generated and evaluated.

This section of the manual outlines the systematic decision-making process necessary to plan a Caltrans monitoring project that will achieve project-specific goals and objectives, including the development of appropriate DQOs. The process includes the following seven steps that summarize the systematic planning process:

KEY TOPICS

- **Determine Project Goals and Objectives**
- **Identify Resources and Constraints**
- **Identify Data Characteristics and Tools**
- **Determine Key Study Parameters**
- **Specify Methods for Obtaining Data**
- **Develop Performance/Acceptance Criteria**
- **Optimize the Design for Obtaining the Data**

A flow chart of the systematic planning process as applied to Caltrans projects is included as Figure 1 below.

In many cases, the initial steps in the process discussed here will already be determined by the Caltrans Stormwater Management Plan and the Monitoring and Research Strategy. These steps are reviewed below for planning related to Caltrans stormwater monitoring projects.

➢ DETERMINE PROJECT GOALS AND OBJECTIVES

The initial step in the development of a monitoring program[1] is to determine the goal of the project based on the task order or problem statement presented by Caltrans. The overall goal of the study will in most cases have been defined previously in the Caltrans Stormwater Management Plan (SWMP) and other planning documents. The purpose of the monitoring project is then to provide data in fulfillment of the study goals. Once the program goals and purpose are established, a set of specific study questions and objectives should be compiled.

Determine Project Goal

As listed in the SWMP, goals for a planning-support monitoring program should involve one or more of the following key activities:

[1] Any stormwater monitoring conducted by Caltrans is likely to be part of a broader, statewide, Caltrans stormwater monitoring program. In this document, the terms "project" and "program" are used interchangeably to refer to any monitoring effort conducted under the statewide program.

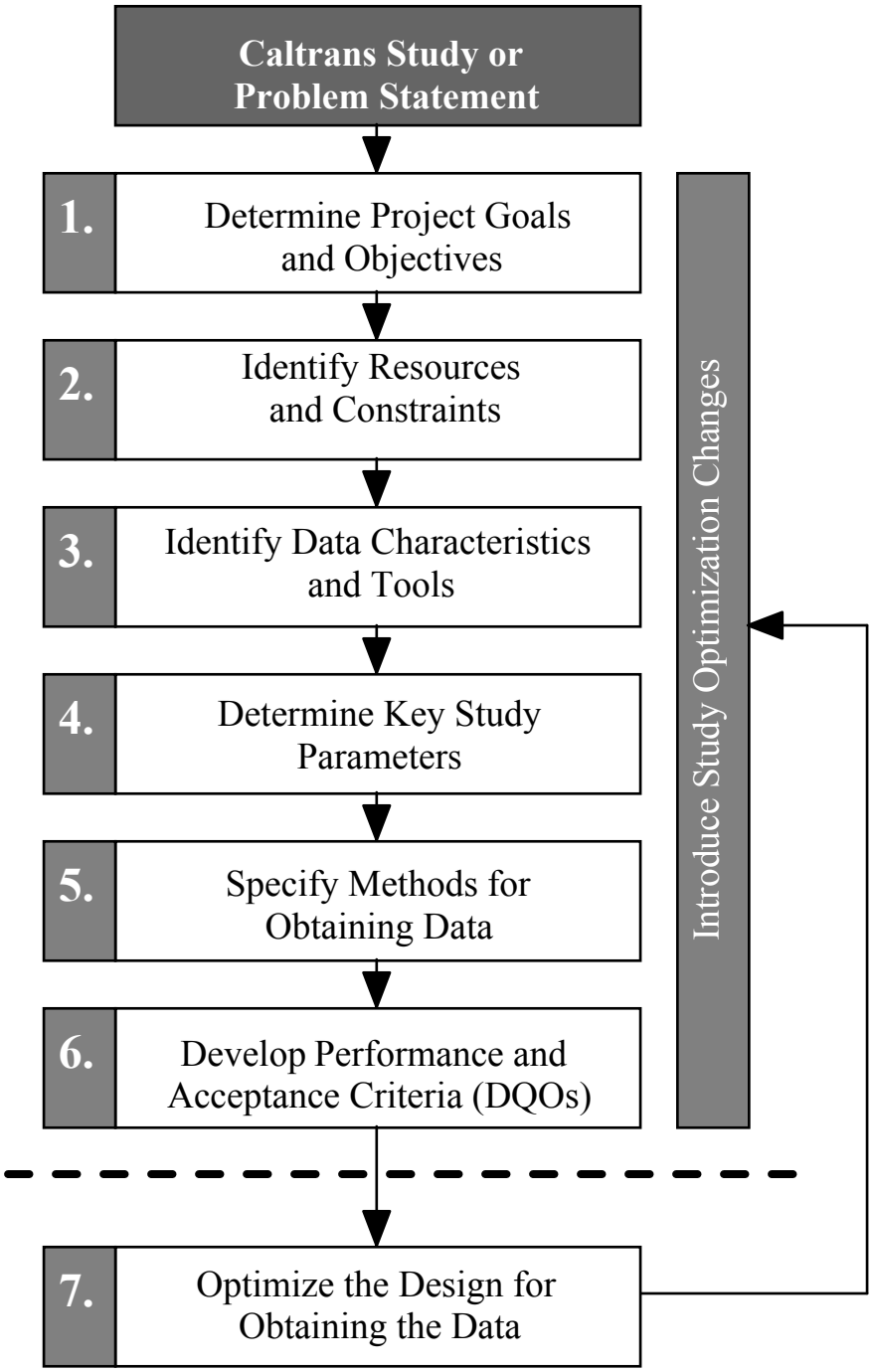


Figure 2-1. Systematic Planning Process Flow Chart

- Identification of factors that affect the concentrations and loads of problem constituents in transportation runoff,
- Identification of the physical and chemical mechanisms that affect the mobilization, transport, and transformation of problem constituents, and/or
- Evaluation of costs, effectiveness, and benefits of stormwater management practices (BMPs).

While the project goal is most often determined by Caltrans in previous planning documents or in the applicable task order, the project goal may need to be refined or restated once additional data are collected or additional resources and constraints are identified.

Once the goal of the study is well defined, the project purpose can be stated so as to direct the project to provide data to fulfill the study goal. The goal and purpose of the study are strongly linked.

Determine Specific Study Questions/Objectives

The statement of purpose and program goals should be used to develop specific questions that the monitoring program will be designed to answer. These study questions are also in may cases previously defined in the Caltrans Stormwater Management Plan (SWMP) and other Caltrans planning documents. Specific monitoring project objectives are then developed to provide answers to the specific study questions.

Any applicable regulatory or legal program requirements must be considered in formulating the key question(s) to be used in defining project objectives. The study questions and project objectives must be specific enough to provide the basis for a detailed study design.

Once study questions and objectives are known, specific project information needs are identified. The information needs must address the identified legal or regulatory requirements of the program, and focus the monitoring planning effort on providing answers to the key question(s) addressed by the project.

➢ IDENTIFY RESOURCES AND CONSTRAINTS

The specific resources available and constraints pertaining to implementing the monitoring project objectives should then be identified. Planned studies are often supported by a body of data resources from previous studies, as well as other existing resources such as personnel, equipment, and services. Studies are typically constrained

by time, available budget, physical limitations of the study area, and practical weather constraints (e.g., number of storms in a year). These resources and constraints must be well established during the planning process. At the start, the systematic planning process assumes that the fiscal constraints on a project are not primary. Practically speaking, budget constraints are known from the beginning and generally affect the scope and detail of the study. The project may also be constrained by applicable regulatory or legal requirements.

➢ IDENTIFY DATA CHARACTERISTICS AND TOOLS

The study design should specify the expected characteristics of the monitoring data and the planned data analysis tools, so as to optimize collection of data within the limitations of the proposed study and ensure that useful results will be provided to fulfill study objectives.

Essential data characteristics include the type of data to be collected (e.g., constituent concentrations), the variables affecting the data (e.g., antecedent conditions, rainfall intensity, site type and location), and the expected variability of the data (derived from previous studies when available). Statistical techniques such as power analysis can then be used to determine key study parameters, such as the number of monitoring locations and storm events to be monitored (see discussion below).

Prior to the initiation of environmental sampling, a strategy should be developed for analysis of the data, directed to answering the specific study questions. The selected data analysis technique(s) may influence the type and quantities of data required to satisfy study objectives. The analysis methods applied to data collected for BMP evaluations or characterization studies typically involve straight-forward statistical operations; however, Caltrans data may be applied to multiple applications in the future (e.g., modeling applications, comparisons to other studies, and assessments of contributions to receiving water loadings), and data should be collected and presented in a manner that will allow the most versatile use of the data.

➢ DETERMINE KEY STUDY PARAMETERS

Key parameters of the monitoring project are determined using the information gathered in the previous steps of the systematic planning process. Key study parameters include site selection (see ***Section 3***), number of monitored storm events and their temporal distribution, characteristics of target storm events, types of samples (composite, grab, etc.) and analytical constituents (see ***Section 4***). The better these characteristics are understood, the more efficiently the monitoring data can be collected.

The monitoring locations can be selected to optimize the physical monitoring of the environmental sample stream(s); this is discussed in more detail in ***Section 3***.

To the extent possible, the numbers of monitoring sites and events should be determined by the numbers and types of data points required to provide statistically significant answers to the key study questions, based on the known controlling variables and the expected variability of the data. Power analysis is a common statistical tool used for such purposes. It is also often helpful to consult with a statistician to identify key issues and variables at this stage of the planning process.

The planned numbers of sites and monitoring events are often constrained by fiscal factors; this involves not only the costs of sample collection, but also the costs of sample analysis. For this reason, the list of analytical constituents is often considered in the early stages of project planning (see ***Section 4***), so the costs of the appropriate sample collection and analysis can be factored into the expected cost per monitoring event. The analytical constituents are often prescribed by regulatory or legal mandate.

The types of storms to be monitored and optimal temporal distribution of monitoring events also should be considered during project planning. For example, if the project objectives include characterizing seasonal variation in stormwater quality, the monitoring events must be adequately distributed throughout the period(s) of interest. Besides seasonal distribution, a number of variables can be considered when selecting types of storms to monitor. These variables could include storm size (rainfall amount), duration, and antecedent conditions (such as number of days since the previous rainfall). Storm selection criteria should be developed to guide project managers in the appropriate selection of monitoring events during the monitoring season.

When developing storm selection criteria prior to a monitoring season (see ***Section 9***), special consideration should be given to allowing for characterization of a full range of the key variables such as antecedent conditions. Simple statistical techniques can be used to determine data collection gaps in previously collected data. These techniques include development of probability plots for key variables and identification of key variable ranges. If data variability has been determined, a power analysis can be used to help determine storm selection criteria and sampling frequency. Statistical expertise should be sought when these technically simpler analyses do not provide sufficient specific guidance.

➢ SPECIFY METHODS FOR OBTAINING DATA

Once the key study parameters are known, appropriate data collection methods are specified (see ***Sections 5, 10 and 12***). This includes the types of samples collected and sample collection techniques (flow-based composite, automated sampling, grab, etc.), the equipment used to collect the samples, the analytical methods, QA/QC procedures, and the specific procedures to be followed in accordance with the physical layout of the study site (e.g., which discharge flows best characterize the highway runoff and the practical considerations for collecting samples at that site). The sample collection methods must

consider the analytical method specifications for containers, sample type, and preservation (see ***Sections 5*** and ***12***).

➢ DEVELOP PERFORMANCE/ACCEPTANCE CRITERIA

The central goal of any monitoring program is to provide scientifically defensible data in fulfillment of program objectives. This goal is best achieved through scientific design of the program and sound technical planning. Statistical methods may be used in the design of the program to determine the optimum number of sampling sites and sampling events (monitoring frequency) that will be needed to fulfill specific project objectives. Performance acceptance criteria, also known as DQOs, should be specified for the project, to help ensure that the data produced by the monitoring program will be useful in addressing program objectives, and to establish meaningful confidence levels for the monitoring data.

DQOs, as defined for this guidance document, specify the quality of data required to support the specified objectives of the monitoring program. DQOs generally are used to determine the level of error considered to be acceptable in the data produced by the monitoring program; in large measure they are used to specify acceptable ranges of field sampling and laboratory performance.

Numerical DQOs should be established for constituent reporting limits, analytical precision, accuracy, completeness, and representativeness. These parameters are discussed in detail in ***Section 13***. The DQOs should be specified in the project Data Quality Evaluation Plan (see ***Section 13***) and referenced in the SAP.

Constituent reporting limits should be set low enough to reliably quantify constituents at meaningful levels. The primary goal of setting acceptable reporting limit concentrations should be to accurately quantify constituent concentrations. All efforts should be made to report constituent concentrations at levels greater than the reporting limit. Program-specific reporting limits may be modified if site-specific data demonstrate that any change would improve the overall quality of collected data and still meet the DQOs. For toxic constituents, reporting limits are set low enough to quantify the presence of the constituent at levels lower than the lowest Recommended Water Quality Criterion published by USEPA, whenever feasible.

Analytical precision and accuracy are often determined by historical laboratory performance; in some cases interlaboratory studies conducted by USEPA or others are used to set these limits. Each project should include a thorough QA/QC data review and evaluation to assess project success in meeting accuracy and precision acceptance criteria (see ***Section 13***).

Completeness refers to the percentage of samples that are sampled and analyzed as planned, for which results are found to be valid following QA/QC data validation (see ***Section 13***). A typical completeness level that can be expected of environmental analysis is 95%. Constituents that occur as common laboratory contaminants, such as phthalates, typically require a less restrictive DQO for completeness.

Representativeness criteria are discussed in detail in ***Section 10*** and are based on storm size, percent storm capture, and total number of composite sample aliquots.

➢ OPTIMIZE THE DESIGN FOR OBTAINING THE DATA

Ideally, the systematic planning process can be iterative for each project, as needed. It is possible to modify study parameters, with approval from the Caltrans task order manager, to optimize data collection to meet study objectives, based on newly collected data and field observations. This can sometimes be done during natural break points of the study (e.g., at the end of the wet season), when data are analyzed and achievement of study objectives is assessed. In some cases, the collected information may indicate modification of the study goals, the collection methods, the analytical constituent list, or the types and frequency of storms sampled.

The systematic planning process, as applied to the Caltrans Statewide Stormwater Monitoring Program, is a synthesis of currently evolving EPA guidance and the practical considerations of overall Caltrans goals (Caltrans, 2000). The seven-step process described in this section is the starting point for structuring specific Caltrans monitoring studies. The remaining sections of this manual carry out and build on these steps, from site selection to QA/QC data evaluation. The seven step process is iterative with the final step providing for feedback to any of the previous six steps.

SECTION 3
SITE SELECTION

Selecting sites for Caltrans stormwater monitoring depends primarily on the program objectives, permit requirements, and parameters of interest. However, once these criteria have been used to establish the number and type(s) of monitoring sites, consideration of the following items will help ensure selection of the most appropriate monitoring locations:

KEY TOPICS

- **Representativeness**
- **Personnel Safety**
- **Site Access**
- **Equipment Security**
- **Flow Measurement Capability**
- **Electrical Power and Telephone**
- **Non-Caltrans Sources**
- **BMP Effectiveness**
- **Site Visit**

Each of these considerations is discussed in detail in this section. If program goals include evaluation of BMP effectiveness, additional considerations may be needed to select appropriate sampling locations. Such additional considerations are outlined in the latter part of this section.

➢ REPRESENTATIVENESS

Types of sampling sites specified for Caltrans monitoring may include highway sites (freeways, expressways and/or conventional highways), maintenance yards, park-and-ride lots, or construction sites. It is important to select specific monitoring sites that are representative of typical Caltrans operations for these site types. The following discussions provide guidance on site characteristics to consider when selecting representative monitoring sites.

Highway Sites

Several considerations must be used in the selection of appropriate highway stormwater sampling sites, including permit requirements, traffic volume, grade, and location relative to other land uses. Sampling may be conducted at various locations in Caltrans Districts,

such as ramps, 2-lane highways, multiple lane freeways, etc. Although certain monitoring areas may be specified by a permit, factors such as traffic volume, grade, and surrounding land uses should still be considered when selecting the exact location within the specified area. The following considerations will help to ensure selection of sites that are representative of highway runoff:

- Permit Requirements

  Selection of monitoring sites may be influenced by specific permit requirements. All stormwater and non-stormwater discharges from Caltrans highways and highway-related properties, facilities, and activities are regulated under a National Pollutant Discharge Elimination System (NPDES) permit. Sites that are selected in fulfillment of a permit provision may require the approval of the permitting agency (check specific permit language for any such requirement)).

- Traffic Volume

  The selected sampling site should be located where the traffic volume is comparable to the average range of daily traffic volumes in the respective Caltrans District for the type of highway being studied. Selecting sites with typical traffic volumes may help ensure that the sites are representative of normal conditions. Check with the local Caltrans District office for typical ADTs, as well as the annual compilation of highway traffic volumes published by Caltrans (Caltrans, 1999e).

- Uniform Flow

  Sampling sites should be located where runoff flows are relatively well mixed, yet tend to be relatively "stable" or "uniform". To better approach uniform flows, avoid steep slopes (i.e., select sites with pipe slope less than 2% to achieve uniform flows in the subcritical range), junctions, grade changes, and areas of irregular channel shape due to breaks, repairs, roots, debris, etc. Sites should be located where the channel or storm drain is soundly constructed.

- Erosion Potential

  Avoid areas where the potential for erosion is high, such as areas where land has recently been disturbed by construction or other activities, areas with excessively steep slopes, or cut and fill areas where the land surface has not been fully stabilized.

- Surrounding Land Uses

  Select sites that are not likely to be significantly affected by surrounding land uses via atmospheric deposition or flows from non-Caltrans areas. For example, do not select sites in close proximity to agricultural fields that may be sprayed with pesticides, or industrial sites that may contribute airborne constituents, when deposition from those sites may affect on-site concentrations of monitoring project constituents.

- Backwater or Tidal Influences

  Select sampling sites where the runoff will be free-flowing (gravity flow). Avoid areas likely to be affected by backwater and tidal conditions (illustrated in Figure 3-1), as these factors can complicate the reliable measurement of flow and the interpretation of data.

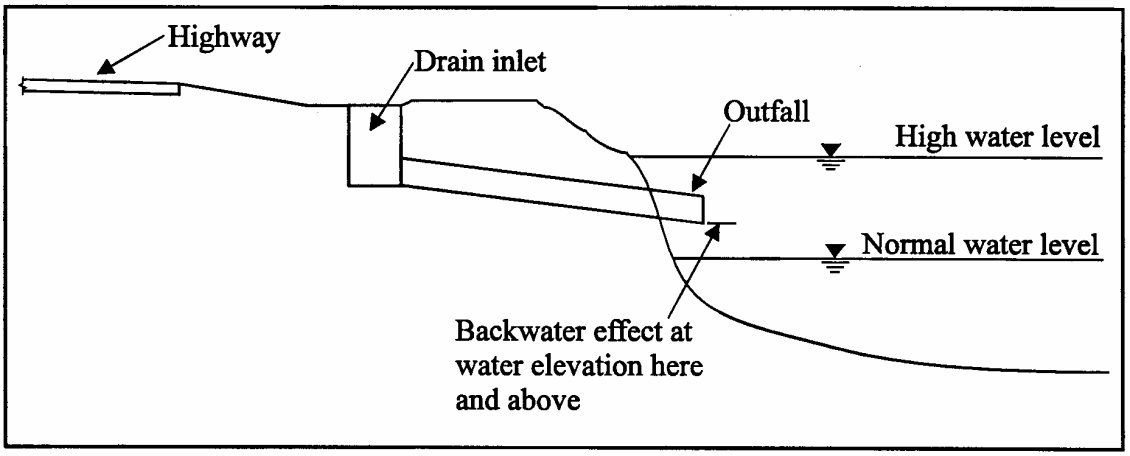


Figure 3-1. Backwater Influence

- High Groundwater Table

  A high groundwater table may influence stormwater runoff if groundwater reaches the surface and mixes with stormwater runoff; therefore, avoid sites where there is a potential for this to occur.

- Illegal Discharges/Illicit Connections

  An inspection of the site should include identification of any signs of illegal discharges, which generally include illegal discharge/dumping of wastes (e.g., used oil and other automotive fluids, trash and debris, etc.) and illicit connections of sanitary sewer lines to the storm drainage system. Selected sites should be free of illegal discharges and illicit connections.

To adequately assess illegal discharges and illicit connections, sites should be visited during dry weather to observe any non-stormwater runoff. The following on-site observations should be made to identify illegal discharges and illicit connections:

- Presence of debris, or rubbish piles on roadway shoulders, at turnouts, in open channels or other areas of the potential monitoring site. Solid waste dumping often occurs on roadways with light traffic loads or in areas not easily visible from the traveled way. Approach containers, such as bottles or barrels, with caution as they may contain hazardous liquids or solids.
- Visible signs of staining or unusual colors to the pavement or surrounding adjacent soils.
- Pungent odors coming from the drainage system.
- Discoloration or oily substances in the water or stains and residues detained within ditches, channels or drain boxes.
- Abnormal water flow during dry weather, including irrigation tail waters.
- Unusual flows in subdrain systems used for dewatering.
- Excessive sediment deposits, particularly adjacent or near active off-site construction projects.

If potential sites are in rural areas, also check for non-standard junction structures and broken concrete, disturbed soil, removed vegetation, or other disturbances at or near junction structures.

All observations should be documented for potential future use. If an illegal discharge or illicit connection is observed on a Caltrans right-of-way, the Caltrans stormwater coordinator should be notified. If the nature of an observed discharge is unknown or suspected of being a hazardous substance, no further investigation should be conducted and the incident reported to the Caltrans stormwater coordinator.

- Significant Transitions

Generally, when considering representative highway sampling sites, it is desirable to select areas that are unlikely to undergo significant transition in the near future. This is to prevent the intrusion of contaminants from construction activities, or other alterations to the monitored area that may cause changes in the quality of the runoff (i.e., cause the quality of the runoff to be atypical of the type of site being monitored). Check with the local Caltrans District office as to whether construction or other significant activities are planned in the area.

Figures 3-2 and 3-3 illustrate a typical highway sampling site in southern California.

Figure 3-2. Representative Highway Sampling Site – Upper

Figure 3-3. Representative Highway Sampling Site – Lower

Maintenance Yards

Locations where highway maintenance vehicles and equipment are stored and serviced may be selected as stormwater monitoring sites. Maintenance activities, including vehicle and equipment cleaning, fueling, and repair, may all contribute constituents of concern to stormwater runoff. Constituents that may be associated with these activities are discussed in ***Section 4.***

Effective monitoring of maintenance yards requires selection of sampling sites that adequately represent typical runoff from the site, prior to mixing with off-site sources. Select sampling sites that have the following characteristics:

- Runoff from the facility has combined to form a definable runoff stream of adequate depth to sample (generally at least ¾" depth).
- The runoff stream fairly well represents the full range of activities at the facility.
- On-site runoff has not combined with runoff from off-site (non-Caltrans) sources.
- Adequate grade or a drop-off exists (e.g., into a drain inlet) to enable collection of runoff samples by placing a sample bottle in the runoff stream (if manual sampling is planned).

Refer also to other conditions described above for selection of highway sampling locations.

Park-and-Ride Lots

Monitoring at park-and-ride lots may be included in Caltrans stormwater monitoring efforts. Effective monitoring of park-and-ride lots requires selection of sampling locations that adequately represent typical runoff from the site prior to mixing with off-site sources. Select sampling sites that have the following characteristics:

- Runoff from the area has combined to form a definable runoff stream of adequate depth to sample.
- On-site runoff has not combined with runoff from off-site (non-Caltrans) sources.
- Illicit connections are not present (refer to highway site section, above).
- Trash receptacles are provided and the area is routinely checked for trash and debris (including illegal dumping).

Refer also to other conditions described above for selection of highway sampling locations.

Construction Sites

Monitoring of highway construction sites may be required as part of legal or regulatory monitoring requirements for Caltrans Districts. Highway construction activities may contribute to increased concentrations of certain constituents (***Section 4***).

Effective monitoring of construction sites requires selection of sampling locations that adequately represent typical runoff from the site prior to mixing with off-site sources. Select sampling sites that have the following characteristics:

- Sampling site should be relatively fixed and stable (not subject to significant modification during construction).
- Sampling site should be in an active area of construction activity.
- Sampling location should not be influenced significantly by construction equipment exhaust.
- Sampling site should be located where runoff leaves the construction site, and where runoff from the site has combined to form a definable runoff stream of adequate depth to sample.

Refer also to other conditions described above for highway runoff and maintenance yards.

➢ PERSONNEL SAFETY

It is essential to ensure monitoring crew safety from such hazards as traffic, explosive or toxic gases, possible injury due to poor footing in slippery conditions, and hazards posed by poor visibility or other challenging conditions during adverse weather, especially at night. Figures 3-4 and 3-5 illustrate monitoring locations that expose sampling personnel to potential traffic hazards.

To help avoid hazards, personnel should be physically capable of performing all tasks required for sample collection and be familiar with the program's Health and Safety Plan. The Health and Safety Plan must be developed prior to the initiation of any sample collection activities and should include information on at least the following: hazard evaluation (e.g. chemical, physical, etc.), contingency plan, personal protective equipment, and emergency information. The requirements of the Health and Safety Plan are discussed in more detail in ***Section 6***.

Information regarding personnel safety during sample collection is provided in ***Section 10***.

Figure 3-4. Avoid Sites Adjacent to Freeway Travel Lanes

Figure 3-5. Avoid Sites that Require Traffic Diversion
(Source:Water Environment Federation, 1993)

➢ SITE ACCESS

Ease of vehicle and personnel access to the monitoring sites for equipment installation and sample collection activities should be assured for the full range of weather conditions that may be encountered. Safe access must be confirmed, especially during wet-weather conditions. For example, ensure that the access point and available parking are at a safe distance from traffic, that any roads to the sampling location are adequate and reliable (e.g., limited potential to be muddy or flooded during wet weather), and that access does not require crossing private property. Check with local agencies as to whether any permits will be required to gain legal access to the sites. Figure 3-6 illustrates an inappropriate sampling location due to poor access.

For stormwater outfall monitoring sites, access into the drainage line/outfall for the flow measuring and sample collection equipment must be feasible and practical. Where practical, access to monitoring sites and equipment should be possible without confined space apparatus or exposure to fast moving traffic, for ease of servicing.

Figure 3-6. Avoid Sites with Poor Access Roads
(Source:Water Environment Federation, 1993)

To ensure that personnel can quickly locate and access monitoring sites, clear directions and site maps should be developed that diagram site access for each sampling site. An example site access map is provided as Figure 3-7. In addition, a list of special access instructions should be included within the Sampling and Analysis Plan (SAP), including information regarding required keys for locks, traffic control requirements, any necessary permits, etc.

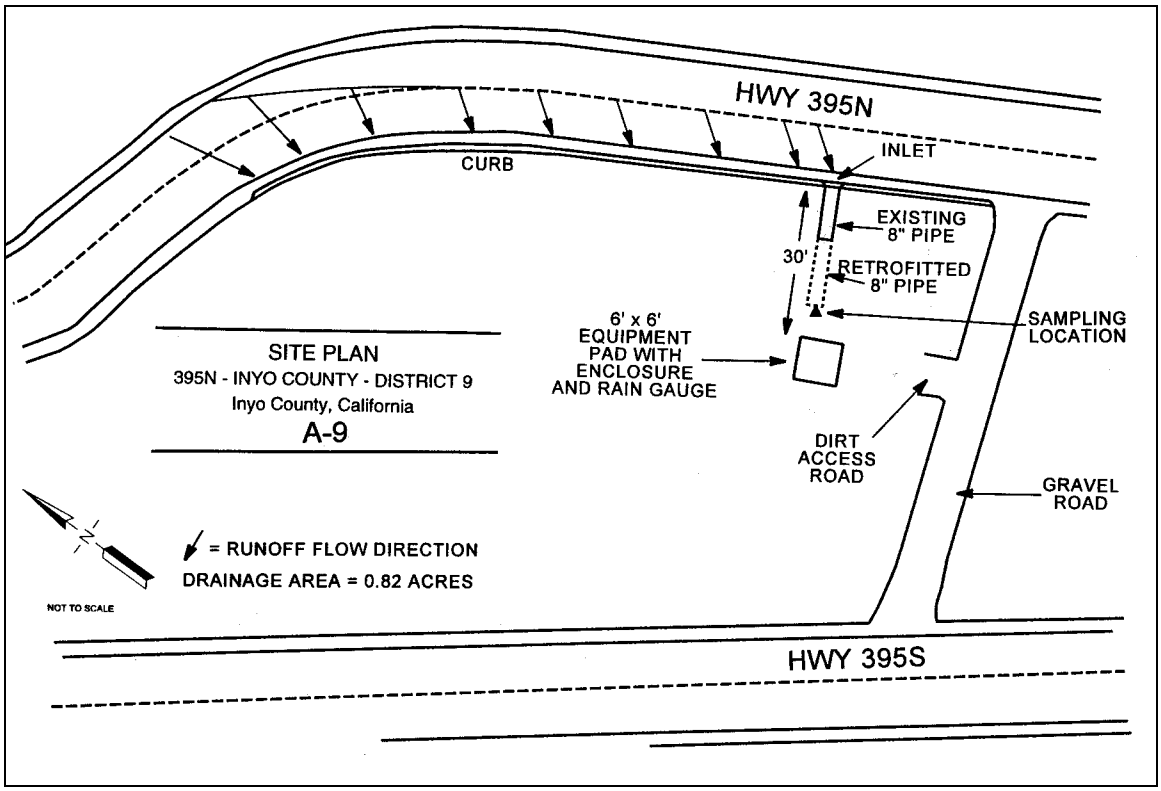


Figure 3-7. Example Site Access Map

➢ EQUIPMENT SECURITY

It is necessary to minimize the susceptibility of automated sampling and flow measurement equipment to vandalism or other possible damage. To ensure security, automated monitoring equipment should be installed in a protective enclosure that is lockable and resistant to vandalism and tampering, as discussed in ***Section 7***. Sites should be selected that have a flat, accessible area that is large enough for installation of any necessary enclosures, including fencing if necessary.

➢ FLOW MEASUREMENT CAPABILITY

Obtaining accurate flow measurements at monitoring stations is necessary to ensure representativeness of flow-weighted composite samples, to determine constituent mass loadings, and to assess the relationship between rainfall and runoff to support mathematical modeling. The hydraulic characteristics necessary to allow for accurate flow measurement include a relatively straight and uniform length of pipe or channel with no confluences (i.e., wyes or tees in the storm sewer lines) or grade changes, and the absence of backwater effects. See ***Section 5*** and ***Appendix C*** for information on flow measurement methods and flow proportional sampling, respectively.

Monitoring sites should be selected at locations where flow rate will be adequate under typical storm conditions to provide for both accurate flow measurement and automatic sample collection. This can be checked in advance by roughly calculating the runoff flow depth expected in the pipe during a storm of typical intensity for the study area.

Flow measurement stations should be located sufficiently downstream from inflows to the drainage system to achieve well-mixed conditions across the channel, and to favor the likelihood of "uniform" flow conditions. In the vicinity of a confluence, the flow sensor and sample collection inlet should be placed a minimum of five pipe diameters upstream and ten pipe diameters downstream of any confluence to minimize turbulence and ensure well-mixed flow.

Backwater effects (i.e., the effects of downstream ponding) should be avoided, especially where sampling protocols make use of depth-based flow measurement. Specifically, backwater effects will result in non-uniform flow conditions, which compromise the ability to measure flow when using depth-based methods. In addition, sampling stations in pipes, culverts, or tunnels should be located so as to avoid surcharging (pressure flow) over the normal range of precipitation expected during monitoring events.

➢ ELECTRICAL POWER AND TELEPHONE

Although not essential, direct electrical power is desired at automated monitoring stations for both reliability and maintenance. For example, if line power is available, AC power packs can be used. Use of AC power decreases routine maintenance requirements, as battery changes are not necessary. However, if AC power is not available, DC battery power can be used. See ***Section 7*** for more information.

Telephone lines can be used for remote communication with automated equipment. Telephone access provides a convenient mode of rapidly accessing information from field equipment during field activities. Cellular telephone is a possible alternative if telephone lines are not available. However, cellular phone operations should be thoroughly checked prior to any monitoring activities (e.g., ensure that there is a reliable provider in the area, and test reception).

➢ NON-CALTRANS SOURCES

Monitoring sites should be selected such that the monitored stormwater runoff originates solely within Caltrans freeway systems or facilities. Any site whose drainage area includes other land use types (e.g., commercial, residential, agricultural, etc.) should be avoided to eliminate collection of non-Caltrans flows.

➢ BMP EFFECTIVENESS

The preceding discussion of site selection considerations relates to selection of sampling locations for stormwater discharge monitoring in general terms. Studies of BMP effectiveness involve differing objectives, and the goals of BMP monitoring programs are somewhat different as well.

There are two general types of BMPs: structural and non-structural. Structural BMPs typically have well-defined boundaries and may be relatively easy to monitor. If evaluation of structural BMPs is part of the program objectives, monitoring locations should be located immediately upstream and downstream of the structure. Monitoring at these locations will enable comparison of stormwater quality influent to the BMP with stormwater quality effluent from the BMP. Such comparisons can be used to evaluate the BMP's performance in reducing constituent concentrations. The comparisons can also demonstrate the effectiveness of the BMP in reducing constituent loads, if both constituent concentrations and flow rates are measured. It is important to design such a study to include accurate flow measurement methods and sampling locations that are representative of the inflow and outflow, so as to produce credible, scientifically defensible data.

Structural BMP performance monitoring may also take place within the BMP (e.g. detention basin), where temporal changes in constituent concentrations and constituent accumulations can be examined.

When selecting sampling locations to evaluate the effectiveness of BMPs, it is important to realize the limitations that may exist, for example:

- The physical setting of the BMP may not allow the use of automated systems.
- Access to either the influent or effluent flow for manual sample collection may be restricted by the physical configuration of the device.
- Accurate flow measurement through the device may be difficult or impossible to obtain.
- Performance of the BMP may be affected by the level of maintenance required under various conditions.

Non-structural BMPs (e.g., street sweeping, catch basin cleaning, illicit discharge elimination) may be more difficult to monitor because they can be influenced by many factors that cannot be "controlled", and may not have clearly defined inlet and outlet flows. In such cases, it may be necessary to monitor the same sites before and after BMP implementation; or to monitor one set of sites where the BMP is applied, and another set of "control" sites, where the BMP is not applied. Selection of comparable representative sites is particularly crucial for such studies. According to work sponsored by USEPA (Clusen and Spooner, 1993), it is recommended that paired sites be selected to:

- Be initially similar in physiographic and biological features, such as size, general morphology, slope, location, soils, and land cover.
- Be similar in past, present, and future human influence, except for the treatment (BMP) being tested.
- Be in a steady state at the outset of the study (i.e., no substantial changes have occurred over a number of prior years).
- Be small enough to obtain uniform treatment over the entire treatment area.
- Have a stable channel at the measurement point, especially for flow monitoring.

It is also recommended that the assignment of the control site versus the treatment site be done randomly.

➢ SITE VISIT

Each potential monitoring site should be visited to confirm the expected site characteristics and verify whether the site is suitable for the needs of the program. When possible, a visit should be conducted during or after a storm, when the discharge flow conditions can be observed. A wet-weather visit can provide valuable information regarding logistical constraints that may not be readily apparent during dry weather. However, a dry weather visit should also be conducted to observe any non-stormwater flows.

A list of criteria, specific to the program objectives and including the considerations discussed in this section, should be developed prior to visiting potential sites. These criteria should be used to produce a site visit log form, which should be filled out during each site inspection. An example of a site visit log is presented as Figure 3-8.

Criteria to be documented during a site visit may include type of site, drainage area characteristics, type of runoff, whether an appropriate sampling location exists, potential safety issues, site access, whether accurate flow measurement is achievable, and if telephone and electrical power are available.

In addition, a check list may be useful to record whether certain conditions exist at a given site, such as: tidal influences, illegal dumping, illicit connections, high groundwater table, erosion, runoff from landscaped areas, adjacent commercial farming, contributing residential runoff, or nearby industrial sites. Once these observations have been made, it is possible to determine if the site is representative of Caltrans highways, and appropriate for the objectives of the project.

Figure 3-8. Site Visit Log*

** example log only; specific site logs should be developed based upon program objectives*

Date _____ Name of person conducting site visit _____

District _____ Location _____ Post Mile _____

TYPE OF SITE:

Roadway	☐	Construction	☐	Park-and-Ride	☐
Landscape	☐	Maintenance Yard	☐	Other	☐

*Describe:*_____

Is the drainage area 100 percent representative of site type?

_____

*Describe:*_____

TYPE OF RUNOFF FROM SITE:

Curb and gutter ☐ Overland flow ☐ Other ☐

*Describe:*_____

POTENTIAL SAMPLING LOCATION (WITH ACCESS TO FLOW):

Storm drain inlet	☐	Ditch, swale	☐
Culvert	☐	BMP (e.g., retention basin)	☐
Pipe	☐	Other (describe)_____	☐

Comments: _____

ACCURATE FLOW ACHIEVABLE? ☐ yes ☐ no

*Describe:*_____

ELECTRICAL POWER AVAILABLE? ☐ yes ☐ no

TELEPHONE LINES AVAILABLE? ☐ yes ☐ no

CLEAR CELLULAR PHONE RECEPTION AT SITE? ☐ yes ☐ no

VEHICULAR SITE ACCESS? ☐ yes ☐ no

*Describe:*_____

PERSONNEL SAFETY ISSUES? ☐ yes ☐ no
(e.g., Proximity to traffic lanes, steep embankments, etc.)

*Describe:*_____

SITE CONDITIONS/OBSERVATIONS ***(if yes, describe)***

Tidal influences yes ☐ no ☐

_____

Illegal dumping yes ☐ no ☐

_____

Illicit connections yes ☐ no ☐

_____

High groundwater table yes ☐ no ☐

_____

Erosion yes ☐ no ☐

_____

Runoff from landscaped areas yes ☐ no ☐

_____

Adjacent commercial farmingyes ☐ no ☐

_____

Contributing off-site runoff yes ☐ no ☐

_____

Adjacent industrial sites yes ☐ no ☐

_____

Is site representative of Caltrans Highways and/or Facilities? yes ☐ no ☐

*explain*_____

Other observations: _____

_____

SECTION 4
CONSTITUENT SELECTION

To select the specific list of analytical constituents for monitoring at a given location, the following items should be considered:

KEY TOPICS

- **Project Objectives and Resources**
- **Regulatory and Legal Requirements**
- **Pollutant Sources in the Catchment Area**
- **Existing Monitoring Data**
- **Beneficial Uses/Impairments of the Receiving Water**
- **Constituents to Be Used for Data Interpretation**
- **Typically Monitored Constituents**

Each of these considerations is discussed below, followed by a list of the suite of analytical constituents typically monitored in Caltrans projects.

A summary schematic of the process followed in compiling the analytical constituent list for a given project is shown in the flow chart in Figure 4-1. The procedure calls for examining the purpose and goals of the project, legal requirements, existing permits and BMP objectives (if applicable), and adding or subtracting constituents from a typical list of Caltrans monitoring constituents. Consideration of sampling and analysis costs (i.e., available project resources) is included as a final step in making this determination, as most projects are fiscally constrained. This process allows selection of constituents that are the most appropriate for inclusion in the monitoring plan.

A list of analytical constituents typically included within Caltrans stormwater monitoring projects is provided in Table 4-1. Existing data from previous studies conducted by Caltrans form the essential basis for this typical minimum suite of analytical constituents. In some cases it may be prudent or necessary to add additional constituents to this list, for example to address legal requirements or specific receiving water concerns

In ***Appendix B***, two additional tables are provided for reference. These tables summarize all the data collected by Caltrans monitoring projects from 1997 to 1999. Information in these tables includes the number of samples, percent detected, ranges of the detected values, and water quality limits set out in the California Toxics Rule (CTR) and the California Ocean Plan.

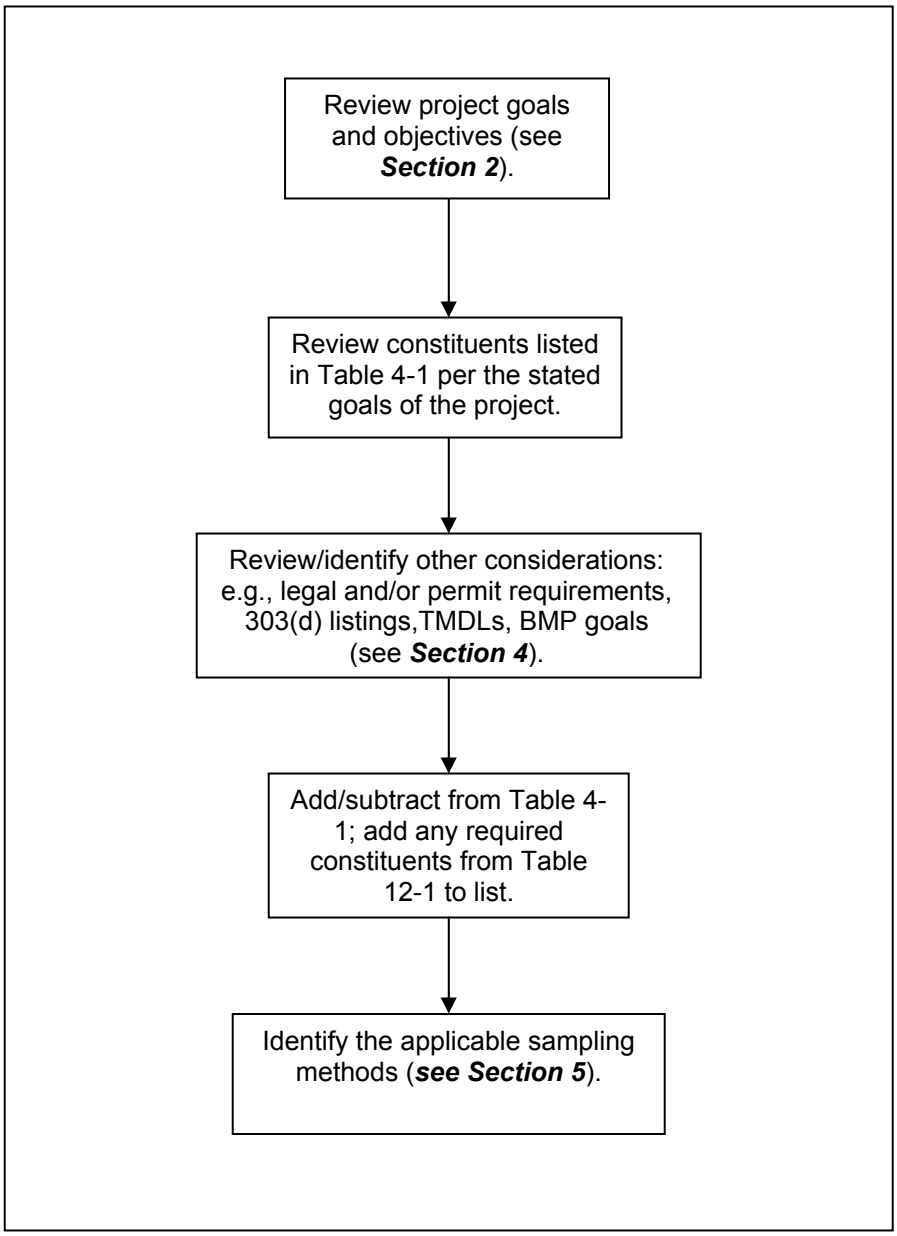


Figure 4-1. Flow chart of constituent selection process.

Table 4-1. Minimum Constituent List for Characterization[1]

	Units	*RL*
Constituent/Parameter name		
Conventional		
Conductivity	μmhos/cm	±1[2]
Hardness as $CaCO_3$	mg/L	2
pH	pH Units	±0.1[2]
Temperature	°C	±0.1[2]
Total Dissolved Solids (TDS)	mg/L	1
Total Suspended Solids (TSS)	mg/L	1
Dissolved Organic Carbon (DOC)	mg/L	1
Total Organic Carbon (TOC)	mg/L	1
Nutrients		
Nitrate as Nitrogen (NO_3-N)	mg/L	0.1
Total Kjeldahl Nitrogen (TKN)	mg/L	0.1
Total Phosphorous	mg/L	0.03
Dissolved Ortho-Phosphate	mg/L	0.03
Metals (total recoverable and dissolved)		
Arsenic (As)	μg/L	1
Cadmium (Cd)	μg/L	0.2
Chromium (Cr)	μg/L	1
Copper (Cu)	μg/L	1
Lead (Pb)	μg/L	1
Nickel (Ni)	μg/L	2
Zinc (Zn)	μg/L	5
Organic Compounds[3]		
Diuron	μg/L	1
Glyphosate	μg/L	5
Oryzalin	μg/L	1
Oxadiazon	μg/L	0.05
Triclopyr	μg/L	0.1

[1] For analytical methods and other specifications, see ***Table 12-1*** in ***Section 12***.

[2] Refers to instrument resolution.

[3] Analysis for the listed herbicides applies to Caltrans statewide characterization monitoring only; this analysis may not be appropriate or necessary for other types of projects.

➢ PROJECT OBJECTIVES AND RESOURCES

The list of constituents selected for a monitoring program will ultimately depend upon the program objectives and available resources (personnel, funds, time). As discussed in ***Section 2*** and the Annual Monitoring and Research Strategy Report Update (Caltrans, 2000), the primary purposes of Caltrans monitoring programs are to:

- Advance the state of knowledge regarding the water quality implications of stormwater and non-storm flows from highways and related Caltrans facilities;
- Provide a sound basis for optimizing elements of the Caltrans stormwater management program to improve effectiveness; and
- Implement a Caltrans stormwater management program that complies with the Clean Water Act.to provide planning-support for Caltrans' stormwater management program.

Key objectives that pertain to the selection of analytical constituents include:

- Identification of factors and sources that affect the concentrations and loads of problem constituents in runoff from transportation facilities;
- Identification of the physical and chemical mechanisms that affect the mobilization, transport, and transformation of problem constituents from transportation facilities;
- Evaluation of costs, effectiveness, and benefits of stormwater management practices (BMPs).

The principal focus of these objectives is to provide information that will assist Caltrans in identifying stormwater best management practices (BMPs) that would be most likely to yield significant environmental benefits to receiving waters. Therefore, it is appropriate to refine the list of analytical constituents for specific monitoring projects to focus on those constituents likely to be controlled through specific BMPs. In turn, it is possible to conduct a narrowly focused study, targeting specific constituents to evaluate BMP effectiveness (i.e., a BMP may be targeted toward controlling some well-defined, locally important problem caused by a particular constituent or combination of constituents).

➢ REGULATORY AND LEGAL REQUIREMENTS

Constituents specified for analysis by regulatory requirements (including NPDES permit provisions) or legal (court-ordered) requirements should be included within the list of analytical constituents.

➢ POLLUTANT SOURCES IN THE CATCHMENT AREA

Identifying potential constituent sources in the catchment area can aid in the selection of analytical constituents. Caltrans projects may involve monitoring of runoff from highways, maintenance yards, park-and-ride lots, and construction sites. The potential constituent sources associated with each of these facilities may differ.

Highway runoff

Fossil fuel combustion, wear of tires, brake pads, bearings, bushings and other moving parts in engines, leaking lubricants and hydraulic fluids, and road deicing are processes that may contribute constituents of concern to highways. Highway runoff has been characterized during previous Caltrans NPDES permit compliance monitoring efforts. Numerous constituents, including metals, petroleum hydrocarbons, polynuclear aromatic hydrocarbons (PAHs), phenols, nutrients, bacteria, and various conventional parametersconstituents, have been detected in highway runoff. As discussed later in this section, existing Caltrans highway runoff data should be used to select help guide in the selection of analytical constituents. (i.e., select constituents known to be prevalent in stormwater from highways).

In addition, as mentioned in ***Section 3***, the area monitored may not be 100 percent representative of highway runoff (i.e., may include vegetated areas). Other land uses in the area may warrant inclusion of additional parametersconstituents. For example, if a large portion of the area is vegetated, it may be important to include analysis of the chemicals (e.g., pesticides) recorded to have been applied to these areas.

Maintenance yards

The activities that take place at maintenance yards, including vehicle and equipment cleaning, fueling, and repair, may contribute various constituents to stormwater, including synthetic organic compounds (e.g., from adhesives, cleaners, sealants, solvents) and petroleum hydrocarbons. Throughout the United States, heavy metals (namely chromium, copper, lead, nickel and zinc), oil and grease, nutrients and solvents have been associated with runoff from vehicle service/maintenance activities. In addition, eroded sediment, the primary source of suspended material, may be a site-specific concern at some maintenance yards.

Park-and-Ride Lots

Petroleum products, metals, sediment, bacteria, and trash and debris may be present in stormwater runoff from park-and-ride lots. Coliform (Total and Fecal) bacteria may be present in runoff at varying concentrations. Further investigation is underway within the scientific community, since the transport mechanism has not been identified.

Construction sites

Construction sites can be sources of suspended solids in stormwater runoff. Suspended solids (sediment) may be deleterious to aquatic life, but it is also a transport medium for other constituents, including nutrients, trace metals, and hydrocarbons. Caltrans routinely implements BMPs to contain suspended solids (sediment) generated at construction sites. BMPs include structural controls such as silt fences and straw bales, and non-structural activities including good practices.

➢ EXISTING MONITORING DATA

Caltrans (1999c) has monitored highway runoff for a number of parameters, and a number of other Caltrans monitoring projects have been completed within recent years. These data have been useful in identifying constituents that appear frequently in highway runoff, as well as those that are rarely or never detected. Caltrans data collected during the 1997-98 and 1998-99 rainy seasons are summarized in ***Appendix B***.

Evaluation of recent Caltrans data revealed numerous constituents that were rarely or never detected in highway runoff. Table B-1 (***Appendix B***) lists the number of times each constituent was analyzed, the percent detection, the minimum and maximum concentrations detected, and the reported source(s). Table B-2 presents the water quality objectives set forth in the California Toxics Rule and the California Ocean Plan. Constituents that are often not detected include volatile organic compounds, such as those known to be components or byproducts of gasoline. These compounds are not often detected in stormwater because they are highly volatile and therefore do not persist in the environment. Additionally, original concentrations of these compounds are presumed in most cases to be relatively low.

➢ BENEFICIAL USES/IMPAIRMENTS OF THE RECEIVING WATER

Information on receiving water quality within a stormwater drainage system can be used to indicate whether discharges from Caltrans facilities have the potential to adversely affect the receiving water body. For instance, constituents known to be associated with highway and transportation-related facility runoff can be compared with the constituents of concern identified in major receiving waters, to determine if highway or transportation-related facility runoff have the potential to impact receiving water quality.

Caltrans guidance should be consulted regarding high priority receiving waters within each Caltrans District, to determine whether any constituents of concern should be added to the analytical constituents list for a particular project. ***Appendix B*** provides information on potential impacts of specific constituents on receiving water quality.

➢ CONSTITUENTS TO BE USED FOR DATA INTERPRETATION

The usefulness of data generated through runoff monitoring can be enhanced by collection of additional supporting data. For example, hardness should be determined in order to effectively analyze the impact of several metals (e.g., cadmium, chromium, copper, lead, nickel, silver, and zinc), which have hardness-dependent toxicity levels and regulatory levels of concern. Additionally, the analysis of both total and dissolved metals will enable effective comparisons to water quality criteria (WQC). Temperature and pH values are needed to help assess ammonia speciation and toxicity.

➢ TYPICALLY MONITORED CONSTITUENTS

If a significant number of problem constituents are identified from the criteria discussed in this section (e.g., constituent sources, existing monitoring data, legal requirements, receiving water impacts) or if inclusion of certain constituents is questionable, a two-phased approach may be considered. During the first phase, conduct an initial screening by analyzing samples collected from the first one or two storms (preferably storms occurring after extended dry periods) for a broad range of parameters of potential concern. Parameters not detected, or measured at levels well below concern, can be dropped from subsequent monitoring efforts (second phase).

SECTION 5
SELECTION OF MONITORING METHODS AND EQUIPMENT

This section discusses the various methods and equipment that may be used for sample collection and flow measurement. In addition, appropriate methods of data management are discussed.

Water quality in stormwater runoff may vary both laterally and vertically throughout the cross section of flow, and with time. For instance, floatable materials (oil, grease, light particles and debris, scum) may be present in significant amounts near the water surface, while heavier sediments are often concentrated near the bottom of the conveyance. Also, concentrations of some constituents may be higher in the first hour or two of runoff; this is often referred to as a "first flush" effect. During the course of a storm, rainfall intensity also may increase, raising runoff flow rates to the point where sediments are mobilized and scour occurs, resulting in temporarily higher concentrations of sediment-bound constituents.

The stormwater monitoring program should be designed to ensure that collected samples are representative of runoff quality throughout a given storm event. Ideally, this means collection of flow-proportioned composite samples throughout the runoff hydrograph. See ***Appendix C*** for a discussion of flow-proportional compositing.

This section is organized under the following subsections:

KEY TOPICS

- **Sample Collection Methods**
- **Sample Collection Equipment**
- **Flow Measurement Methods and Equipment**
- **Precipitation Measurement**
- **System Integration**
- **System Command/Control**
- **Remote Communication**
- **Data Management**

➢ SAMPLE COLLECTION METHODS

Stormwater samples can be collected to represent a point in time (i.e., "grab" sample) or a period of time (i.e., "composite" sample). A grab sample is essentially a one-time collection of a sample volume adequate to perform the intended water quality analysis. A composite sample is comprised of some number of individual sample aliquots mixed together. For stormwater monitoring, this usually refers to samples collected sequentially over time during a stormwater runoff event.

Stormwater samples can be collected using either manual or automated means. Districts should select the combination of sample types and techniques most suitable to the monitoring program objectives and available resources. In most cases, automated composite sampling is the recommended sample collection method, with manual grab sampling as required for certain constituents (as discussed below and in ***Section 10***).

Composite Sampling

Automated sampling generally is the most cost effective method of composite sample collection, and is particularly appropriate for large-scale programs (e.g., where a large number of sampling sites are monitored, or numerous sampling events are conducted over multiple years). Automatic samplers can be configured to collect flow-proportioned (flow-weighted)[1] composite samples, which provide the most accurate means for estimating EMCs[2] and pollutant loads. Pollutant loads can be calculated using the EMC and runoff volume (see ***Appendix C***).

Automated monitoring systems are comprised of electromechanical devices that can be operated automatically (i.e., an on-site operator is not needed). Automated monitoring is recommended for the following reasons:

- Personnel are not required to be on-site; therefore, worker safety is not threatened by hazardous conditions (e.g., traffic, inadequate oxygen, toxic or explosive gases) and after hours labor requirements are reduced.
- Automatic samplers can be programmed so that sampling operations are initiated when pre-determined conditions are met, such as a specific flow rate, flow depth, or rainfall amount. This reduces the possibility of missing the early stages of runoff.
- Automated equipment can be programmed in conjunction with a flow meter to collect flow-weighted composite samples, using a constant volume proportional flow method (***Appendix C***). This permits collection of representative samples throughout the storm event.

The key elements of an automated monitoring system that are required to collect flow-proportioned composite samples include:

<u>Sample Collection</u>:

---

[1]Discussion of flow measurement methods is presented later in this section. Flow-proportioned (flow-weighted) composite sampling is discussed in more detail in Sections 9 and 10.

[2]The event mean concentration (EMC) is a statistical parameter that describes the average concentration of a given constituent at a specific location during a storm event. The EMC should be representative of the complete runoff hydrograph, and can be defined as the total constituent mass transported in the runoff, divided by the total runoff volume. The EMC is normally derived by analytical measurement of the constituent concentration in one or more representative composite samples. Flow-proportioned composite sampling for the purpose of determining EMCs is further discussed in ***Appendix C***.

- An automatic sampler,
- Sample intake tubing and strainer, and
- Sample bottle(s).

Flow Measurement:

- A flow measurement device,
- Flow sensor and cable, and
- Optional rain gauge.

Data Recording/Retrieval:

- A data storage device,
- System software,
- Optional remote communications capabilities, and
- Optional secondary/back-up power source.

These components are discussed individually later in this section.

Composite samples also may be collected using manual methods. This approach may be warranted when the sampling program is to be of limited scope or duration, or where the installation of automated sampling equipment is economically or logistically infeasible. Although manual composite sample collection is more labor-intensive during a storm event, it will reduce required station setup and maintenance prior to each storm event. See ***Section 10*** for a description of manual compositing techniques.

Grab Sample Collection

A grab sample is an individual sample collected at one specific site at one point in time. Analysis of a grab sample provides a "snapshot" of stormwater quality. Grab samples are required for monitoring parameters that transform rapidly, require special preservation, or adhere to bottles. For example, samples to be analyzed for oil and grease, petroleum hydrocarbons, ammonia, volatile organics, and bacteria are required to be collected as grab samples only.

Grab samples are most often collected using manual methods and equipment. Some grab samples may be collected using intermediate containers and some (oil and grease, petroleum hydrocarbons) may not. When use of an intermediate container is appropriate (e.g., for ammonia, volatile organics), grab samples should be collected by holding an appropriate container (bucket, bailer, sample bottle, etc.) under the outfall of a discharge pipe, at the lip of an inlet grate, or by dipping a container downstream of a discharge with the container opening facing upstream, depending on monitoring site configuration. The sample is then poured immediately into the appropriate grab sample bottle. Samples for bacteriological analysis must be collected in sterile bottles. Sterile Teflon bailers are

available for this purpose; otherwise, the sample must be collected directly into the sterile "bacti" bottle. Clean techniques must be used when collecting bacteriological samples (see ***Section 10***).

When collecting samples for oil and grease or petroleum hydrocarbon analysis, the sample must be collected directly into the bottle that will be used in the laboratory, because petroleum-derived compounds may adhere to the sample container (the laboratory analyzes samples for these constituents by extracting the entire contents of the sample bottle). Because oil and grease and other petroleum hydrocarbons tend to float, these grab samples should be collected at the air/water interface.

➢ SAMPLE COLLECTION EQUIPMENT

For all collection efforts, sampling devices must be made of chemical resistant materials that will not affect the quality of the stormwater sample. In general, suitable sampling devices should be constructed of one of three materials: Teflon, glass, or polyethylene. These materials are known to be the most inert in terms of adsorption or desorption of organic and inorganic compounds, although both glass and plastic are subject to certain use limitations, depending upon the type of constituent being measured, as discussed below.

All sampling equipment used for trace metals determinations must be nonmetallic and free from any material that may contain metals. Acceptable materials include Teflon, polyethylene, and borosilicate glass (e.g., Pyrex). All sampling equipment used for trace organics determination must be glass or Teflon. All sampling equipment used for bacteriological determination must be sterile. Polyethylene or glass sampling equipment and bottles should be used for collection of nutrients. Borosilicate glass is generally adequate for composite sample collection when analysis is to be performed for a mixture of organic and inorganic constituents. See ***Section 12*** for specifications of acceptable bottle materials for each analytical constituent.

It is important to evaluate each component of the sampling device (e.g., bottle lids, connections, tubing) for possible sources of sample contamination. For example, latex and neoprene rubber tubings should be avoided because latex is organic and neoprene rubber may contain trace metals. Butyl rubber seals may also contaminate samples for organic analysis.

Equipment that is constructed of stainless steel, such as dippers or sample intake strainers, may be Teflon-coated to make them suitable for use in a stormwater monitoring program.

Automated Sampling Equipment

Key components required for automated sample collection include an automatic sampler, tubing with strainer, and sample bottle(s).

Automatic Sampler

Automatic samplers are comprised of a peristaltic pump, pump control electronics, a sample distribution system, a power supply, and a housing that contains the composite bottle(s). A peristaltic pump creates suction by compressing a flexible tube with a rotating roller, drawing a sample that is then pushed out of the pump. The pump operates best when placed close to the source; this reduces the suction head or lift (experience has shown that the reliability of peristaltic pumps drawing a consistent sample volume is greatly reduced as the static suction head increases). According to manufacturer's specifications, vertical lift must be no greater than 26 feet. When sampling with an automated sampler, static head height refers to the vertical distance from the surface of the flow stream to the automatic sampler pump inlet.

Automatic samplers may be configured for single or multiple bottle composite collection (see Figures 5-1 and 5-2 for examples of single and multi-bottle configurations). Samplers configured to fill multiple sample bottles have a sample distribution mechanism. Tubing from the discharge port of the intake pump is connected to a rotating distributor arm that dispenses the samples into several sample bottles.

If flow-weighted sampling is planned, the automatic sampler must be capable of accepting a signal from a flow meter that is used to trigger collection of a sample aliquot. Cables can be purchased that connect each type of flow meter to an automated sampler.

Automatic samplers are equipped with internal memory circuits, and typically a small LCD data screen. The memory holds the user-programmed values for the sample aliquot volume, sample bottle configuration, and number of samples per bottle. The memory also retains information describing the status of the sampling program and the time at which each triggering signal was received from the flow meter. Messages can be displayed on the data screen for the user regarding any sample collection failures.

Samplers are powered by 12 volt DC batteries, AC power, or solar-powered batteries. Two types of 12V DC batteries are available: nickel-cadmium and lead-acid. Most automated sampler manufacturers offer AC power packs for use where line power is available. Use of AC power decreases routine maintenance requirements, as battery changes are not necessary. The preferred configuration includes AC power with an in-line battery backup. However, back-up batteries typically will not provide adequate power for refrigerated units.

Figure 5-1. Single Bottle Configuration for Automatic Composite Sample Collection

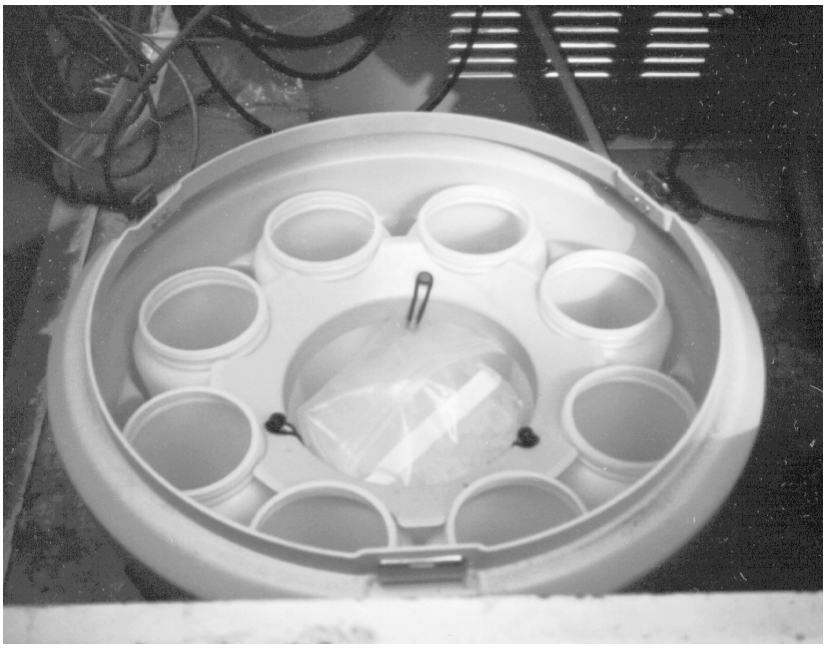


Figure 5-2. Multiple Bottle Configuration for Automatic Composite Sample Collection

Sampler Intake Strainer, Intake Tubing and Flexible Pump Tubing

The intake strainer is attached to the intake tubing and mounted to the bottom of a pipe or channel. Intake strainers prevent rocks and debris from clogging or damaging the intake tubing or pump. Sizes vary, but smaller intake strainers are generally better for use under low flow conditions. Sample intake strainers is typically made of stainless steel, or a combination of stainless steel and Teflon. For trace metals analyses, all intake strainer parts must be Teflon, or coated with Teflon or Teflon-like material. See ***Section 7*** for guidance on intake strainer placement.

Specific intake and pump tubing requirements are listed below:

Intake tubing:

- Teflon
- Maximum vertical lift = 26 feet
- Maximum length = 99 feet

Pump tubing:

- Silicon or other medical grade flexible tubing
- Limit to length needed to feed through peristaltic pump, connect to Teflon intake tubing and sample bottle

Teflon tubing is used for the sample intake tubing because of its inert properties. This tubing is connected from the intake strainer to the pump tubing, and may range from 3 to 99 feet in length. EPA protocols permit the use of the minimum amount of flexible pump tubing needed to carry the sample water through a peristaltic pump (illustrated in Figure 5-3). Silicone tubing is normally used for this purpose.

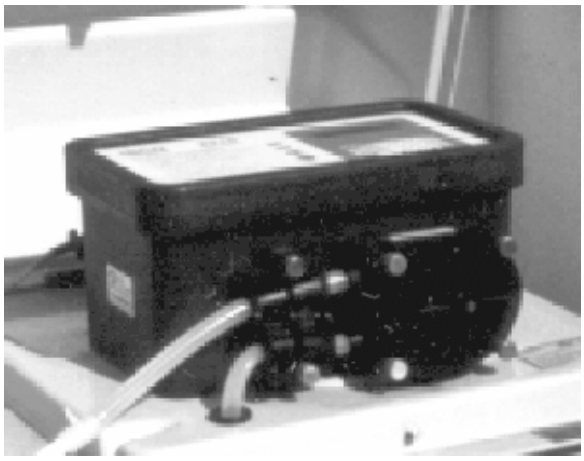


Figure 5-3. Peristaltic Pump

Sample Bottle(s)

Automatic samplers may be configured to have a variety of sample bottles, from one to a dozen or more sample bottles. If a sampler holds a single bottle, all of the sample aliquots are pumped into this bottle, resulting in one large composite sample. Use of a single composite bottle has the advantage of providing for the estimation of the event mean concentrations (EMCs) directly from analysis of the constituents in the one bottle. However, it does not allow for isolation of specific samples or groups of samples from specific periods of the runoff hydrograph, and provides less visual indication of sampler malfunction (if this should occur). A multiple bottle configuration, however, provides these latter capabilities.

It is important to keep extra bottles (for either the single or multiple bottle configuration) available in case bottles are contaminated or damaged, or in the event that bottles need to be changed to accommodate a larger-than-expected storm. If a storm delivers more precipitation than expected, sample bottles will fill prior to the end of the storm, prompting sample bottle replacement.

In-situ Analytical Measurement Equipment

Electronic equipment is available for certain field-measured analytical parameters (e.g., turbidity, conductivity, pH). Electronic sensors and data loggers may allow for near-continuous measurements of indicator parameters at reasonable cost. This equipment also makes it feasible to monitor every storm that occurs over a period of time, including short-duration events that would otherwise be impractical to monitor. In addition, data reduction and evaluation are simplified because the water quality results are simply downloaded from the data logger onto a laptop computer or a personal computer with a modem. However, it is important to realize the limitations associated with the use of sensors and data loggers:

- Sensors are only available to measure a limited number of parameters.
- The ion-specific sensors now available may not provide low enough detection limits to meet monitoring project DQOs.
- It may be difficult to assure the quality (i.e., precision & accuracy) and reliability of the results.
- Laboratory analysis is required in conjunction with the results to allow correlations to be made between the indicator readings and concentrations of specific constituents of concern.
- It may not be possible to reliably correlate a sensor-measured "indicator" parameter with a given constituent of concern.
- Sensors are subject to fouling or clogging from debris, algae, oil & grease, etc.
- Some sensors (e.g., turbidity) may require substantial flow for accurate readings.

- Some sensors (e.g., pH, conductivity) cannot be allowed to dry out; this is problematic in many drainage conveyances.

Manual Sampling Equipment

Manual sampling is required for the collection of certain samples, including samples to be analyzed for bacteriological analysis, oil and grease, petroleum hydrocarbons, and others (see ***Section 10***). Manual equipment can include hand-operated items such as bailers, grab poles or other items designed to lower an appropriate sample container into the runoff flow. This equipment is relatively inexpensive and easy to maintain. All grab sampling equipment which directly contacts the sample during or after collection must be compatible with the specific constituents to be analyzed, as discussed previously.

➢ FLOW MEASUREMENT METHODS AND EQUIPMENT

Flow measurements are required for accurate sample compositing. Flow rate may be measured manually or with automated equipment. Manual measurements can be made using the volume-based bucket and stop watch method, the velocity-based float method, or various depth-based methods (which are also appropriate for automated sampling). Automated flow measurements can be made with electronic depth measurement or area/velocity measurement devices. Making accurate flow measurements is typically a difficult task. For additional reading regarding flow measurement see *Isco Open Channel Flow Measurement Handbook* (Isco, 1997), Douglas M. Grant & Brian D. Dawson (fifth edition).

The flow measurement method selected will depend upon the conditions at a given site; no one approach is suited to all conditions. The following are some factors to consider before selecting the flow measurement method to be used at a particular site:

- Applicability of the method to site conditions,
- Accuracy of the method,
- Ease of measurement during a sampling event, and
- Ease and cost of installation of the measurement device.

This section contains information on several manual flow measurement methods, including the bucket and stopwatch method, the float method, and various depth-based methods, including the use of flumes and weirs. This section also discusses automated methods of flow measurement that are applicable to monitoring stations designed for flow-proportioned, composite sampling.

Manual Flow Measurement Methods

Listed below is information on several manual flow measurement methods, including the bucket and stopwatch method, the float method, and depth-based methods.

Bucket and Stopwatch Method

The basis for the "bucket and stopwatch method" is the collection of a measured amount of flow over a measured amount of time to directly determine flow per unit of time (flow rate) using the following equation:

$$Flow\ rate\ (cms) = \frac{Volume_{bucket}\ (gal.) * 3.785\left(liters/gal.\right)}{time\ (\sec) * 1000\left(liters/m^3\right)}$$

As a general rule, the bucket should be large enough (or the flow small enough) so that it takes at least five seconds to fill. If the bucket fills in less than 5 seconds, it will be difficult to accurately estimate the flow rate.

Float Method

Using the float method, the flow rate is calculated from the measured velocity of the flow and the cross-sectional area of the discharge using the following equation:

Flow rate (cms) = Velocity (meter/sec) * Area (sq. meter)

Current velocity is measured as the time it takes a float to travel between two points separated by at least 5 feet (approx. 1.5 meters). Examples of good floats are oranges, lemons, and limes, articles which have a specific density similar to water and tend to float totally submerged. These floats truly reflect current velocity, are not affected by wind or bottom snags, and are easily observed. In addition, these floats do not persist in the environment if they are not recovered after flow measurements are taken.

Depth of flow is also measured in the vicinity of the velocity measurement. The cross-sectional area of flow is calculated from the measured depth, based on the known geometry of the pipe or channel.

The product of velocity and cross-sectional area is then calculated to produce the flow rate.

Depth-Based Methods

A depth-based flow measurement method estimates flow rate directly from the measurement of flow depth, using a predetermined relationship of flow depth and discharge rate. The depth-based method can incorporate the use of a flume or weir, but can also be used under uniform flow conditions within a pipe or channel of known geometry to determine the depth-discharge relationship. Depth can be measured manually (i.e., with a hand-held ruler or via an electronic depth measurement device).

Flumes

A flume is a specially built reach of channel (sometimes a prefabricated insert) that has a converging entrance, a throat section, and a diverging exit section (see Figure 5-4). The throat area or slope (or both) of the flume is designed to differ from that of the channel, inducing a depth of flow which is proportional to flow rate. For each type of flume there is a functional relationship (described by a mathematical equation) between depth and flow rate.

To estimate flow rate, use a yardstick to measure depth (for manual monitoring) or a continuous depth meter attached to a data logger or computer that converts data from depth-of-flow measurements to estimates of the corresponding flow rate, based upon the flume's dimensions. If using the latter, use the empirical equation provided by the manufacturer. If depth is measured manually, prepare a stage-discharge table using the equation for the specific flume (i.e., calculate the estimated flow rate for each depth of flow using the appropriate equation).

Weirs

A weir is a vertical obstruction built or placed across an open channel (or within a pipe if it flows under open channel conditions) so that water flows over the weir's top edge (or through a well-defined opening in the plate). A weir can be used to regulate flow in a natural channel with irregular geometry, a situation where Manning's equation, for example, cannot provide reliable estimates. However, a weir is intended to back up water by creating a partial dam. During large storm events, the ponded water could overflow the weir structure, invalidating the weir equation. In addition, sediments and/or debris which accumulate behind a weir can alter the hydraulic conditions, changing the empirical relationship between depth of flow and discharge rate. Therefore, weirs should be regularly inspected and accumulated sediment or debris removed. If excessive sedimentation deposition and accumulation occurs, use of a flume may be more appropriate as they avoid these problems.

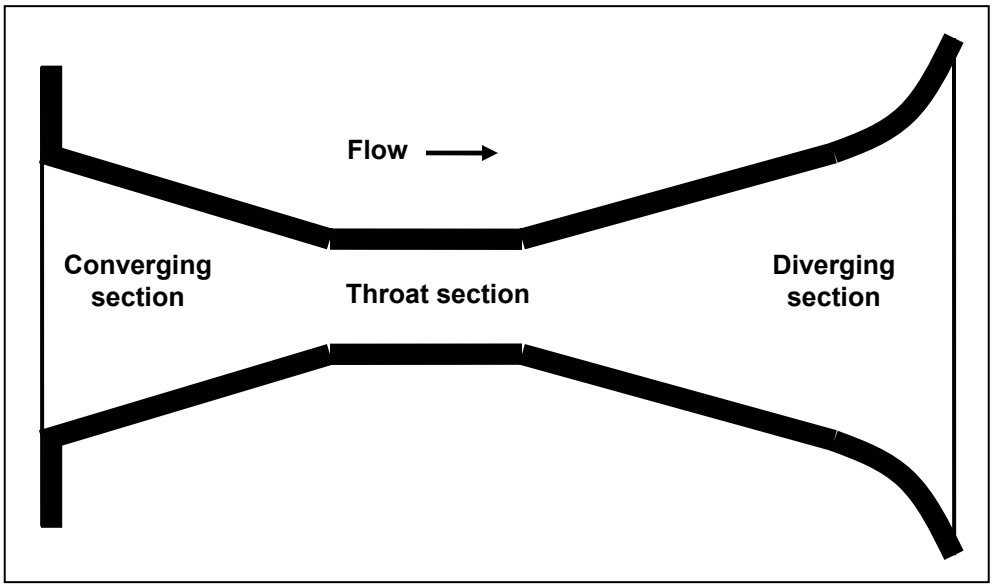


Figure 5-4. General Flume Configuration
Source: ISCO Open Channel Flow Measurement Handbook (5th ed.),1997.

Pipe or Channel

Flow rate can also be estimated with the depth-based method without the use of a flume or weir, in any pipe or channel of known geometry, material, and gradient. Depth measurement is used together with Manning's equation (see Figure 5-6) and the known pipe characteristics to calculate flow, based on an assumed relationship of depth to flow rate, given the specific characteristics of the conveyance.

This method may be applied in areas where the flow is uniform, non-turbulent, and not affected by changes in direction or grade. It is also essential that the flow remain free-flowing, and not affected by downstream backwater or surcharge conditions.

Electronic Depth Measurement Devices

Electronic depth measurement devices are typically used for automatic flow measurement by providing a means to electronically measure flow depth and automatically convert depth to flow rate, using the known geometry of the conveyance and the appropriate depth/discharge equation. The following types of depth-measuring devices, which convert level measurements to flow rates with accuracy of $\pm$15%, are available from manufacturers such as ISCO and American Sigma:

Bubbler: The depth of the flow is determined by measuring the pressure needed to force bubbles out of a line submerged in the flow stream.

Pressure Transducer: The pressure of the liquid above a pressure sensor is measured to determine the depth of the flow stream.

Ultrasonic: Depth is measured by transmitting an ultra sound pulse from the sensor mounted above the stream, and measuring the time for the echo to return from the flow stream surface. This measuring device must be placed in a secure location, where it will not be affected by wind, temperature flux, etc.

Each of these options is illustrated in Figure 5-5 .

These devices use internal circuitry to calculate flow rate from the measured depth, typically by use of the Manning equation (Figure 5-6), with user-input pipe or channel characteristics. The measured depth is first used to calculate the cross-sectional area of flow, based on the known geometry of the pipe or channel. The cross-sectional flow area is the input into Manning's equation to compute instantaneous flow rate.

Because the Manning equation assumes essentially unrestricted gravity flow (subject only to the friction provided by the pipe or channel surface), anything that alters the flow path or otherwise restricts free flow will cause deviations from the value calculated by the Manning equation. Examples include: imprecisely known or non-uniform slope of the conveyance; physical deterioration of the pipe or channel surface; the presence of standing water or downstream "backwater" conditions; and the presence of substances in the water that would alter its normal fluid characteristics. The presence of extraneous flow inputs or outputs, including infiltration and exfiltration, also may cause the Manning equation to overestimate or underestimate flow.
Manning's equation was developed for uniform slopes of less than 0.1ft/ft. Therefore, other flow measuring techniques should be explored for monitoring sites that do not meet this criterion.

See Table 5-1 for typical examples of Manning roughness coefficient "n" for various channel configurations. For additional Manning "n" values, refer to Table 851.2 of the *Caltrans Highway Design Manual, 5th Edition "Manning n-values for alternate pipe materials*" (Caltrans, 1999d).

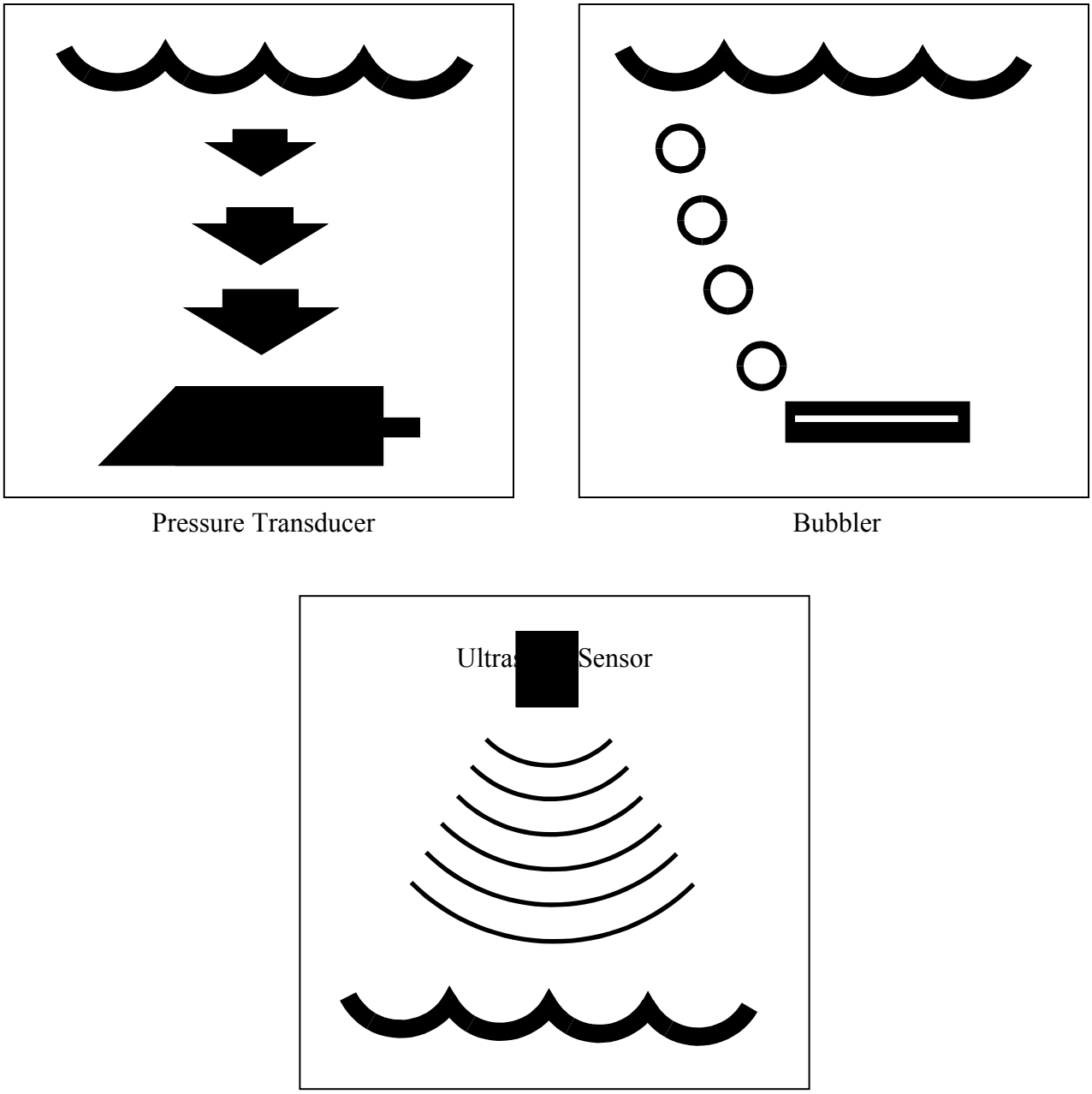


Figure 5-5. Depth Measurement Devices

$$Q = \frac{1.486}{n} * A * R^{2/3} * \sqrt{S}$$

where:

Q = flow rate, ft^3/sec

n = Manning's roughness coefficient, dimensionless (when used with the English units specified for the other input variables)

A = cross sectional area of flow, ft^2

R = hydraulic radius, ft (R=A/WP, WP = wetted perimeter in ft.)

S = slope of the energy grade line (slope of the conduit), ft/ft

Figure 5-6. Manning's Equation

Table 5-1. Examples of Typical Manning Roughness Coefficient "n"

	Min.	*Norm.*	*Max.*
Closed Conduit – partly full			
Corrugated storm drain	0.021	0.024	0.030
Brick lined with cement	0.012	0.015	0.017
Concrete culvert, straight	0.010	0.011	0.013
Concrete culvert with bends, connections & some debris	0.011	0.013	0.014
Concrete sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
Unfinished concrete, steel form	0.012	0.013	0.014
Unfinished concrete, smooth wood form	0.012	0.014	0.016
Unfinished concrete, rough wood form	0.015	0.017	0.020
Rubble masonry, cemented	0.018	0.025	0.030
Lined or Built-up Channels			
Corrugated metal	0.021	0.025	0.030
Mortar finish cement	0.011	0.013	0.015
Trowel finish concrete	0.011	0.013	0.015
Float finish concrete	0.013	0.015	0.016
Unfinished concrete	0.014	0.017	0.020
Cemented rubble masonry	0.017	0.025	0.030
Smooth asphalt	0.013	0.013	-
Rough asphalt	0.016	0.016	-
Excavated or Dredged			
Earth, straight and uniform	0.016	0.022	0.035
Earth, winding and sluggish	0.023	0.030	0.040
Unmaintained channels	0.040	0.070	0.140
Natural Channels			
Fairly regular section	0.030	0.050	0.070
Irregular section with pools	0.040	0.070	0.100

Source: ISCO Open Channel Flow Measurement Handbook (5th ed.),1997.

Area/Velocity Measurement Devices

Flow rate may be measured automatically with an area-velocity flow meter. This technology combines use of an electronic velocity sensor with a depth-measurement device. The velocity sensor typically uses Doppler technology or electromagnetics to measure average velocity throughout the flow stream. The depth measurement is converted to cross-sectional area of flow, using user-input channel or pipe geometry. The flow is then calculated automatically from the cross-sectional flow area and the velocity.

This technology is more accurate than the use of depth measurement and Manning's equation done under the full range of flow conditions. This capability is particularly important when downstream conditions cause backwater or otherwise impede flow at the point of measurement. In such cases, depth measurement alone would overestimate the actual flow rate from Manning's equation.

This technology is not ideal for extreme low flow conditions. Typically, the velocity sensor has to be completely submerged before accurate readings can be made. Flow below the sensor can account for a significant part of the hydrograph in smaller drainages.

Automated flow meters are designed to take frequent or continuous measurements of depth of flow and/or velocity, and convert the depth and/or velocity into a flow rate as described above. The standard hydraulic equation (Manning's equation) or an empirically-derived relationship is used to automatically convert the measurements to a flow rate. It is important to select the appropriate flow measurement technology for a specific application. A flow measurement technology selection guide is presented as Table 5-2.

Table 5-2. Flow Measurement Technology Selection Guide

	Ultrasonic Sensor	*Pressure Transducer*	*Bubbler*	*Area Velocity*
Suitability for Different Applications				
Weirs and flumes	Excellent[1]	Excellent	Excellent	Excellent
Channels less than 6”	Not recom.	Excellent	Excellent	Not recom.
Small round pipes 6-8”	Good[2]	Excellent	Excellent	Good
Medium round pipes 10-15”	Good[2]	Excellent	Excellent	Excellent
Large round pipes 15-96”	Excellent[2]	Good	Excellent	Excellent
Irrigation channels & small streams	Excellent[2]	Good	Excellent	Good
Rivers & large streams	Excellent[2]	Good	Excellent	Good
Performance Under Adverse Conditions				
Strong wind	Not recom.	Excellent	Excellent	Excellent
Air temperature fluctuations	Very good[3]	Excellent	Very good[3]	Excellent
Foam on liquid	Not recom.	Excellent	Excellent	Excellent
Flow stream turbulence	Not recom.	Excellent	Excellent	Excellent
Floating debris	Not recom.	Excellent	Excellent	Excellent
Floating oil or grease	Not recom.	Excellent	Excellent	Excellent
Suspended solids	Excellent	Very good	Good	Very good
Suspended grease	Excellent	Very good	Good	Very good
Silting in	Excellent	Very good	Good	Very good
Liquid temperature fluctuations	Very good[4]	Good[4]	Excellent	Good[4]
Submerged flow	Not recom.	Not recom.	Not recom.	Very good
Full pipe flow	Not recom.	Not recom.	Not recom.	Very good
Surcharged flow	Not recom.	Not recom.	Not recom.	Very good
Reverse flow	Not recom.	Not recom.	Not recom.	Very good
Maintenance Requirements Caused by Adverse Conditions				
Silting in	Occasional	Occasional	Occasional	Occasional
Suspended solids	None	Occasional	Occasional	Occasional
High grease concentration	None	Occasional	Occasional	Occasional

Source: Introducing ISCO 4200 Series Flow Meters, Accurate Flow Measurement That's Versatile and Easy to Use, Brochure 60-3213-298, 1994.

1. Use with caution in small flumes
2. There must be adequate space above for mounting sensor
3. Large air temperature fluctuations will affect accuracy
4. Large water temperature fluctuations will affect accuracy

➢ PRECIPITATION MEASUREMENT

Precipitation can be measured using either a portable “direct-reading” rain gauge (graduated collector that is read manually) or an electronic “tipping bucket” rain gauge.

Rain gauges serve two major purposes in a stormwater monitoring program. Firstly, collection of rainfall data, when compared with flow data, can provide useful information regarding site hydrology. Secondly, electronic rain gauges can be used to initiate sample collection when used in conjunction with automated sampling equipment. To do this, the electronic rain gauge is connected to a datalogger and a specified rainfall amount is programmed using system software, such that when the target minimum rainfall amount is reached the automated sampler is switched into sample collection mode.

Use of an electronic "tipping bucket" rain gauge is recommended whenever possible, due to the improved accuracy and electronic recordability of the data. This type of rain gauge collects rainfall in increments, usually 0.01 to 0.05 inch, and automatically tips and is emptied after each increment. The rain gauge is normally connected to a datalogger, which counts the number of tips. Total rainfall is recorded automatically by the datalogger.

Use of a portable, direct-reading rain gauge is recommended when automated sampling stations are not available, when the monitoring is being performed at a temporary site, and when field personnel will be present on site to take periodic readings.

➢ SYSTEM INTEGRATION

For the various elements of an automated monitoring system to function effectively, an automated sampling program must include system integration to permit communication among the components and allow downloading of stored data. Manufacturers of automated monitoring equipment, such as ISCO and American Sigma, offer system software that allows integration of automated monitoring equipment such as a flow meter, automated sampler, rain gauge, and other sensors such as a pH, temperature, turbidity, and dissolved oxygen meters. This software also has data logging/retrieval and remote communication capabilities, and the flow meter or sampler can be purchased with a built-in data logger. Other manufacturers can provide custom designed system integrating/data logging software and hardware that allows integration of additional monitoring devices, and provides more advanced command and control options.

➢ SYSTEM COMMAND/CONTROL

Custom-designed system command/control software should, at a minimum, provide the following options:

- System counters for precipitation, runoff volume, sample count, etc., which can be easily reset prior to each anticipated monitoring event.
- Monitoring and non-monitoring modes. Typically when the software is set in "monitoring mode", data collection frequency is increased, and the system is capable of sample collection.
- Monitoring "triggers" or thresholds (e.g., minimum precipitation amount, flow depth, or flow volume). When met, these parameters allow the system to enter "monitoring mode" and initiate sample collection.
- Flow volume per sample (i.e., the flow volume that passes between each composite aliquot collected), for sites that require the collection of flow-proportional samples. See Section 9 for guidance on the calculation of flow volume per sample.

- "Start sampling" and "stop sampling" commands that can be selected, as appropriate, at the beginning of a storm, during bottle changing, and at the end of a storm.
- System data retrieval capabilities.

➢ REMOTE COMMUNICATION

One of the advantages of automated equipment is that it can be controlled remotely. Monitoring stations are controlled and monitored from off-site locations by use of line of sight (LOS) radio, cellular telephone telemetry, or hard-wired telephone, and a computer with a modem and specially designed software. Remote communication is recommended because it facilitates preparation of monitoring stations for stormwater monitoring, and reduces the number of field visits by monitoring personnel. Remote communications also makes it possible to determine more accurately when composite bottles may need to be replaced during a monitoring event.

➢ DATA MANAGEMENT

Efficient data storage, retrieval, and transfer methods should be established prior to initiation of monitoring activities. The following suggestions are provided to guide Caltrans Districts in the development of a reliable and useful data management system:

- Establish a central file for hard copy information; create a system that will ensure that superseded information is not confused with current information.
- Select a database system that can accommodate digital information such as laboratory analyses and recorded data logger measurements.
- Choose a database program that allows for efficient data input, back-up, and retrieval of selected information in response to queries.
- To perform useful queries, include the following categories in the *same* database: sampling event description, catchment area characteristics, sample identification information, sample collection and runoff data, analytical results, analytical methods, and data qualifiers.
- Coordinate electronic data transfer with the analytical laboratory (i.e., the laboratory should provide analytical results in an electronic format that can be directly input into the program's existing database). This can save time and minimize data entry errors.

All storm water monitoring data will be incorporated into the Caltrans Statewide Stormwater Database. See *Caltrans Storm Water Management Program 1999-2000 Data-Reporting Protocols, October 1999* (or latest version), for specific data reporting protocols (Caltrans, 1999c; see also ***Section 14*** and ***Appendix H***).

SECTION 6
SAMPLING AND ANALYSIS PLAN (SAP)

Proper documentation will be required for any Caltrans monitoring program. A stormwater SAP and Health and Safety Plan (HSP) should be prepared prior to initiation of any sampling activities.

This section provides general guidance for preparation of practical, useable SAPs for stormwater monitoring programs. See ***Appendix D*** for detailed information regarding individual components to be included in the HSP.

The following are sections that should be included in a stormwater SAP:

KEY TOPICS

- **Project Overview/Description**
- **Monitoring Site(s)**
- **Analytical Constituents**
- **Data Quality Objectives (DQOs)**
- **Field Equipment Maintenance**
- **Monitoring Preparation and Logistics**
- **Sample Collection, Preservation, and Delivery**
- **Quality Assurance/Quality Control**
- **Laboratory Sample Preparation and Analytical Methods**
- **Data Management and Reporting Procedures**
- **Appendices:**
  - **Clean Sampling Techniques and Equipment Cleaning Protocols**
  - **Health and Safety Plan (HSP)**

Inclusion of these sections will ensure development of a useable and practical SAP. The final product should be a single bound document that can be easily referenced during stormwater monitoring activities. This can be conveniently done by including the HSP as an appendix to the SAP. Printing the SAP/HSP on waterproof paper will reduce the potential for water damage to the document during field use.

All Caltrans stormwater monitoring documentation must be assigned a document identification number prior to document completion. The document identification number, assigned by the Stormwater Management Program document distribution system manager, is used to track the document and develop document distribution lists. Two weeks prior to expected document deliverable date, the author must contact the Caltrans

stormwater management program document distribution system manager to receive a document identification number and mailing labels.

The monitoring objectives, project organization, sampling frequency, sampling site locations and directions to each site, field equipment operation, QA/QC protocols, monitoring constituents, sample collection methods, analytical methods, and logistical details for each project should be documented in a project SAP. The process and criteria for selecting and implementing these monitoring components are described in more detail in ***Sections 2*** through ***5*** (Preparing the Monitoring Plan) and ***Sections 7*** through ***13*** (Implementing the Monitoring Plan).

The SAP should be prepared by someone with a good understanding of field sampling procedures, laboratory analytical methods, and data validation procedures. The analytical laboratory should provide input to ensure that the SAP (especially the QA/QC portion) is realistic, and consistent with the laboratory's operating procedures. Field personnel should also provide input regarding logistical details, and ensure that the plan is practical and easy to use.

The SAP should include a thorough description of all activities required to implement the monitoring program. The plan should be organized to provide an overview of the project goals and organization, followed by a description of all monitoring activities in the chronological sequence in which they will typically occur. That is, pre-monitoring preparations should be described, followed by activities to be undertaken during storm events, followed by post-storm activities. The plan should specify the quality assurance/quality control protocols that will be followed by field and laboratory personnel, and how the field and laboratory results will be managed and reported.

The contents of a typical stormwater SAP are shown in Figure 6-1.

1.0 PROJECT OVERVIEW/DESCRIPTION
- 1.1 Description of why the project is being conducted
- 1.2 Description of who is conducting the project
- 1.3 General scope of monitoring activities
- 1.4 Project organization/roles and responsibilities

2.0 MONITORING SITE(S)
- 2.1 Site location (map)
- 2.2 Written driving directions
- 2.3 Site access instructions (gates, locks, keys, combinations)
- 2.4 Notification procedures

3.0 ANALYTICAL CONSTITUENTS
List of constituents for sampling and analysis (including sample collection method, bottle type, volume required, preservation, and laboratory performing analysis)

4.0 DATA QUALITY OBJECTIVES (DQOs)
- 4.1 Analytical reporting limits
- 4.2 Analytical precision, accuracy, and completeness

5.0 FIELD EQUPMENT MAINTENANCE
- 5.1 Equipment calibration
- 5.2 Equipment maintenance
- 5.3 Equipment cleaning (bottles/lids/tubing)

6.0 MONITORING PREPARATION AND LOGISTICS
- 6.1 Weather tracking
- 6.2 Storm selection criteria
- 6.3 Storm action levels
- 6.4 Communications/notification procedures
- 6.5 Sample bottle order
- 6.6 Sample bottle labeling
- 6.7 Field equipment preparation

7.0 SAMPLE COLLECTION, PRESERVATION, AND DELIVERY
- 7.1 Sample collection methods
- 7.2 Field measurement methods
- 7.3 Field equipment list
- 7.4 Sample containers, preservation, and handling
- 7.5 QA/QC sample collection methods
- 7.6 Sample labeling (site names/codes, etc.)
- 7.7 Composite sample splitting
- 7.8 Forms and procedures for documenting sample collection and field measurements
- 7.9 Laboratory communication procedures
- 7.10 Sample shipping/delivery, chain-of-custody

8.0 QUALITY ASSURANCE/QUALITY CONTROL
Field procedures for QA/QC sample collection

9.0 LABORATORY SAMPLE PREPARATION AND ANALYTICAL METHODS
- 9.1 Laboratory sample preparation procedures
- 9.2 Analytical constituent table (including analytical methods, holding times, and reporting limits)

10.0 DATA MANAGEMENT AND REPORTING PROCEDURES
- 10.1 Analytical data validation
- 10.2 Electronic data transfer
- 10.3 Filing of electronic and hard copy data
- 10.4 Reports

APPENDICES
- A Clean Sampling Techniques
- B Health and Safety Plan

Figure 6-1. Outline for a Typical Stormwater Sampling and Analysis Plan

The following sub-sections further describe the contents of a typical stormwater SAP.

- **OVERVIEW: PROJECT DESCRIPTION, ORGANIZATION, AND RESPONSIBILIES**

This section of the SAP should briefly describe:

- Description of why the project is being conducted,
- Description of who is conducting the project,
- General scope of monitoring activities, and
- Roles and responsibilities of the key field and laboratory personnel who will be involved in the project (typical roles include project manager, sampling coordinator, sampling team leaders, field crew, project QA/QC officer, and laboratory QA/QC manager).

- **MONITORING SITES**

This section should describe the sampling sites selected for the monitoring program and provide rationale for the inclusion of a site. Site selection should be based upon representativeness of land uses in the area, achievable flow measurement, site access, personnel safety, equipment security, and availability of electrical power and telephone. See ***Section 3*** for monitoring site selection guidance.

The following detailed information should be included for each monitoring site:

- Site location map,
- Written driving directions,
- Site access instructions (locked gate keys or combinations), and
- Notification procedures (if notification is required prior to site access).

- **ANALYTICAL CONSTITUENTS**

This section should specify all of the analytical constituents necessary to meet program objectives. See ***Section 4*** for constituent selection guidance. The SAP should include a list of constituents, in tabular form, that includes at a minimum the following columns:

- Constituent name,
- Constituent abbreviation or acronym,
- Sample collection method (i.e. grab or composite),

- Bottle type,
- Volume required,
- Preservation, and
- Laboratory performing analysis.

➢ DATA QUALITY OBJECTIVES (DQOs)

This appendix should specify the project goals and objectives, key project parameters, and the DQOs that were deemed appropriate for the project. Numerical DQOs should be established for analytical reporting limits, analytical precision, accuracy, and completeness. See ***Section 2*** for guidance on the development of DQOs.

➢ FIELD EQUIPMENT MAINTENANCE

This section should include specific information concerning the maintenance of all sampling equipment. At a minimum, all equipment should be maintained according to manufacturer specifications. The following is a list of items that typically require regular maintenance:

- Automatic sampler - calibrate and check battery,
- Intake tubing/strainer - inspect & clear or replace,
- Flow measuring device - calibrate, check battery and check/replace desiccant,
- Rain gauge - calibrate and check for debris, and
- Portable field interments (such as pH meter) – calibrate.

Bottle and equipment cleaning should also be covered in this section of the SAP (see ***Appendix E*** for guidance on sample bottle and equipment cleaning procedures). In addition, if equipment is located in a confined space, this section should include a discussion on the acceptable confined space entry procedures. See ***Section 5*** for guidance on the selection of sampling methods and equipment, and ***Section 7*** for detailed equipment installation and maintenance guidance.

➢ MONITORING PREPARATION AND LOGISTICS

This section should describe the necessary pre-storm preparations including:

- Weather tracking
  - Procedures
  - Responsibilities
  - Obtaining quantity of precipitation forecast (QPF)
- Storm selection criteria

- Stage of wet season
- Antecedent conditions
- Storm duration
- Recommended minimum storm size
- Logistical constraints

➢ Storm action levels

- Non-monitoring
- Standby
- Pre-alert
- Alert
- Go
- Post-storm

➢ Communication/notification procedures

- Telephone tree

➢ Sample bottle order

➢ Sample bottle labeling

➢ Field equipment preparation

- Inspect
- Calibrate
- Charge batteries
- Check

See ***Section 9*** for monitoring preparation and logistics guidance.

➢ SAMPLE COLLECTION, PRESERVATION, AND DELIVERY

This section should provide detailed guidance on standard operating procedures for field personnel (i.e., a concise, useable guide for sampling activities). At a minimum, this section should include:

➢ Sample collection methods to be used at each location,

➢ Field measurement equipment (e.g., pH meter) and methods to be used at each location,

➢ Field equipment that will be required for monitoring at each station (often includes a checklist so field people can ensure they have everything they will need before proceeding to the sampling location),

➢ Sample analyses, containers and preservatives required for each sampling station (usually in table format),

➢ Sample preservation and handling procedures,

- Procedures for collecting and labeling field duplicate samples,
- Sample labeling procedures (site name/code, sample date and time, etc.),
- Sample compositing and splitting procedures (including analytical prioritization for instances of insufficient sample volume),
- Forms and procedures for documenting sample collection and field measurements,
- Laboratory communication procedures, points of contact, and phone numbers, and
- Procedure for sample shipment or delivery to laboratory.

See ***Section 10*** for detailed sample collection guidance.

➢ QUALITY ASSURANCE/QUALITY CONTROL

The QA/QC section should focus on QA/QC procedures necessary for field activities, such as field procedures and collection frequencies for the following:

- Field duplicates
- Laboratory duplicates
- Field blanks
- Equipment blanks
- Matrix/Matrix spike duplicates

QA/QC sample collection frequencies are best presented in a QA/QC sample collection schedule table with a column for each event and a row for each site.

Laboratory QA/QC should be discussed in an appendix and should include the frequency and type of laboratory QA samples (e.g., laboratory duplicates, matrix spikes and spike duplicates, laboratory control samples, standard reference materials), data reporting requirements (electronic and hard copy) and corrective actions. See ***Section 11*** for detailed QA/QC guidance.

➢ LABORATORY SAMPLE PREPARATION AND ANALYTICAL METHODS

This section should describe the activities to be conducted by the analytical laboratory, including sample preparation procedures. A constituent table containing the following information should be presented:

- Constituent name,
- Analytical method,

- Holding times,
- Reporting limit, and
- Reporting units.

See ***Section 12*** for laboratory sample preparation and analytical methods guidance.

➢ DATA MANAGEMENT AND REPORTING PROCEDURES

This section should describe how the analytical data generated from the laboratory and field measurements are to be handled, evaluated, and reported. It should address:

- Analytical data validation (QA/QC review in light of project DQOs),
- Electronic data transfer,
- Filing of electronic and hard copy data,
- Data analysis (e.g., loading estimation, statistical evaluation, etc.), and
- Reports (e.g., quarterly, annual, end of project).

At the beginning of the project, the field and laboratory personnel should review the entire SAP to obtain an overview of their respective roles and responsibilities. Before each sampling event, the field personnel should review the sampling methods section in detail, and the laboratory personnel should review the laboratory sample preparation and analytical methods section. See ***Section 13*** for QA/QC data evaluation guidance. Also see Caltrans Storm Water Management Program 1999-2000 Data-Reporting Protocols, 10/18/99 (or latest version) for data reporting guidance (Caltrans, 1999c; see also ***Section 14*** and ***Appendix H***).

- **APPENDICES:**

Clean Sampling Techniques and Equipment Cleaning Protocols

This appendix should describe clean sample collection and handling techniques, and protocols for cleaning sample collection equipment (e.g. sample bottles, intake tubing, suction tubing, and intake strainers). Clean sampling techniques should be used whenever low-level analytical reporting limits are to be employed for analytical analysis of metals or organic constituents. See ***Appendix F*** for clean sample and equipment handling, and sample collection equipment cleaning guidance.

Health and Safety Plan

Stormwater monitoring involves activities that have the potential to adversely affect the health and safety of field personnel. Stormwater monitoring field crews often work in wet, poor-visibility conditions. Sampling sites may be located along streets or stream channels, or in remote, poorly-lit areas, and may require access on a 24-hour basis. Workers may be exposed to traffic hazards, confined spaces, biological hazards, hazardous materials, fast-moving storm waters, and slippery conditions. Besides monitoring activities during storm events, monitoring equipment installation and maintenance activities may also take place under these conditions.

The information contained herein is for guidance only, and does not supersede or otherwise change any applicable state, local, or agency health and safety requirements or programs.

The general steps in HSP development for a given stormwater monitoring project are listed below:

- Assign a health and safety officer to oversee all health and safety activities.
- Write concise descriptions of all of the field activities that will be included in the program.
- Identify and evaluate the potential physical, chemical, and biological hazards associated with each activity.
- Specify the measures to be employed to reduce the health and safety risks associated with the identified hazards (i.e., precautions).
- Specify health and safety training and documentation requirements.
- Develop an emergency response/contingency plan.

Each of these steps is described in ***Appendix D***. Figure 6-2 contains an example outline for a project-specific HSP.

1.0 Introduction

2.0 Project And Safety Personnel

3.0 Site Information

4.0 Work Activities Covered By Health And Safety Plan

5.0 Hazard Assessment
- 5.1 Chemical Hazards
- 5.2 Confined Spaces
- 5.3 Physical Hazards
- 5.4 Biological Hazards

6.0 General Health And Safety Requirements
- 6.1 Employee Clearance
- 6.2 Site Safety Meetings
- 6.3 Accident Reporting
- 6.4 Prohibited On-Site Activities
- 6.5 Communications

7.0 Site-Specific Health And Safety Requirements
- 7.1 Special Medical Tests
- 7.2 Special Training
- 7.3 Physical Hazards
- 7.4 Hazardous Materials Identification And Protection
- 7.5 Confined Space Entry
- 7.6 Traffic Control
- 7.7 Personal Protective Equipment
- 7.8 Site Illumination
- 7.9 Biological Hazard

8.0 Emergency Response Procedures
- 8.1 Hospital Information
- 8.2 Emergency Route to Hospital
- 8.3 First Aid & Related Equipment

Figure 6-2. Typical Outline for a Health and Safety Plan

IMPLEMENTING THE MONITORING PLAN

SECTION 7
EQUIPMENT INSTALLATION AND MAINTENANCE

This section provides guidance for the installation and maintenance of stormwater monitoring stations that are equipped with automated monitoring equipment. Automated monitoring stations typically include the following basic elements:

KEY TOPICS

- **Protective Equipment Enclosures**
- **Power Source**
- **Flow Meter**
- **Automated Sampler**
- **Rain Gauge**
- **Confined Space Entry**
- **Bottle and Equipment Cleaning and Installation**

➢ PROTECTIVE EQUIPMENT ENCLOSURES

Stormwater monitoring stations containing automated monitoring equipment require a proper protective enclosure that is lockable, resistant to vandalism and tampering, and provides protection from the elements. In areas where equipment tampering may be a concern, the protective enclosures should be surrounded by chain link fencing with a locked gate and razor wire along the top. Figure 7-1 illustrates security for a sampling station equipped with steel enclosure, chain-link fencing, and razor wire.

There are two basic types of enclosures typically used to house monitoring equipment: 1) a heavy gauge steel box with hinged lid, and 2) a walk-in shed type enclosure. The advantages of a walk-in enclosure include shelter for field personnel from rain, more room for field crew to work, and storage for extra sample bottles and equipment. However, walk-in enclosures tend to be more costly than box type enclosures.

The protective enclosure should be secured to a concrete pad, with all wiring and tubing entering/exiting the enclosure routed through appropriately sized conduit. Examples of typical steel box and walk-in monitoring station enclosures are presented in Figures 7-2 and 7-3.

➢ POWER SOURCE

Commercially available automated stormwater monitoring equipment typically has the capability of running on either AC or DC power. At monitoring stations where AC power is available, the preferred setup is to operate the equipment using AC power with DC battery backup. This will allow monitoring to continue in the event of a power

outage. However, refrigerated samplers cannot be powered by DC power. Making AC power available to a monitoring station typically involves having an electrician run power from nearby power lines to a metered fuse box, and finally into the enclosure.

Sampling locations that do not have AC power lines nearby typically make providing AC power cost prohibitive. At installations where AC power is not readily available, automated monitoring equipment must be powered using DC batteries. Solar panels may be installed to provide continuous DC battery charging. Immediately prior to each stormwater monitoring event, all monitoring equipment batteries should be checked and replaced with freshly charged batteries, as necessary.

Figure 7-1. Example of Equipment Security

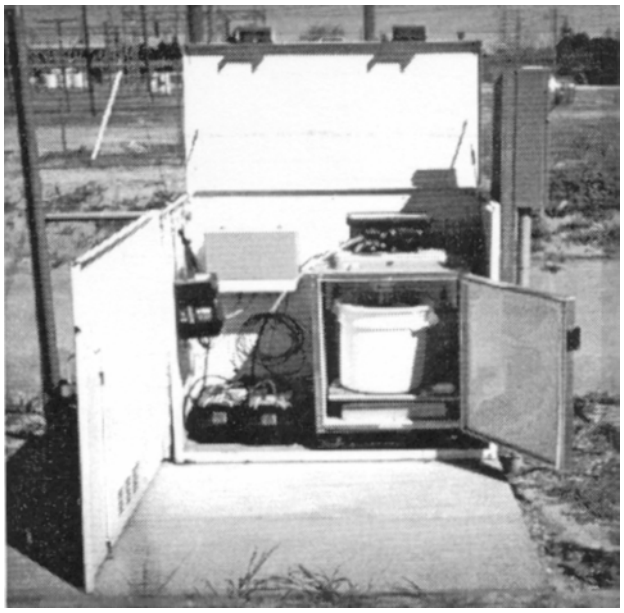
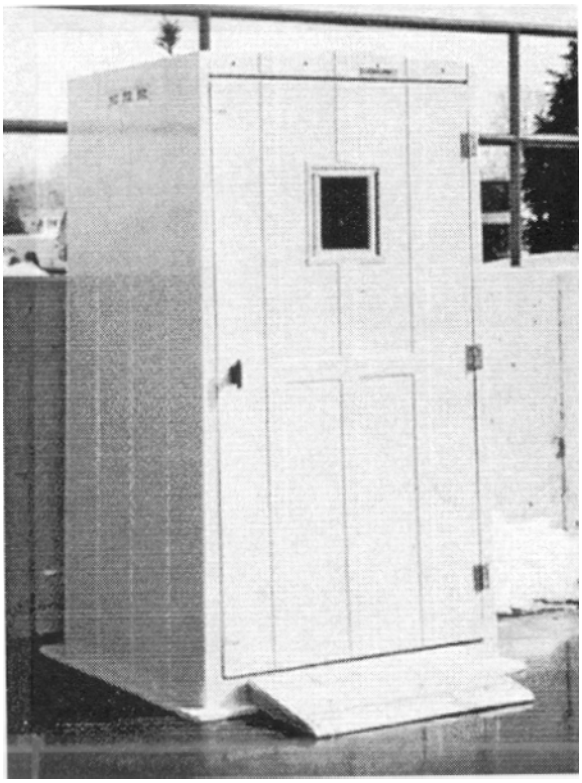


Figure 7-2. Steel Box Monitoring Station Enclosure



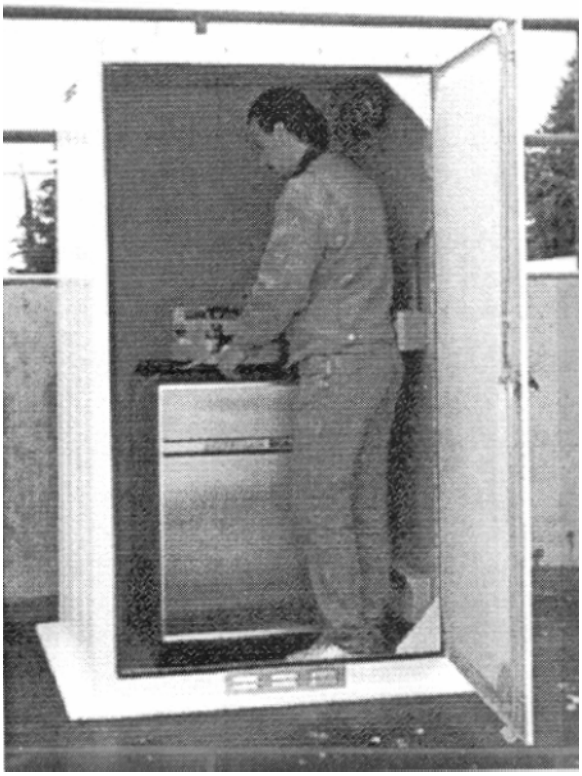


Figure 7-3. Walk-In Monitoring Station Enclosure
(Source: American Sigma, Model 6989)

➢ FLOW METER

There are two basic types of flow measuring devices typically used for flow weighted stormwater sampling: 1) depth sensors, which convert level measurements to flow rates based on the known pipe or channel geometry and an assumed relationship of depth to flow rate (usually using Manning's equation – see Figure 5-5), and 2) area velocity measuring devices, which measure both the depth and velocity of flow to produce a more accurate estimation of flow rate. The applicability of flow measuring devices and Manning's equation are described in detail in ***Section 5***.

Flow monitoring equipment should be installed and maintained according to manufacturer specifications. Flow monitoring equipment should be calibrated, at a minimum, according to manufacturer recommended frequencies. For some applications, more extensive calibration procedures may be required to insure accurate flow measurement.

Installation

The flow meter should be securely fastened to the inside of the protective enclosure in such a way that all controls, display windows, and cable connections are easily accessed. All cables entering/exiting the flow meter should be secured, in a well organized fashion, to the inside of the protective enclosure. This will reduce the potential for accidental disconnection or damage.

The flow monitoring sensor(s) must be installed in the channel, pipe, or flume according to manufacturer specifications. Typically, stainless steel expanding bands are used to mount sensors inside pipes. Sensors may also be mounted at the base of the channel, pipe, or flume using a stainless steel base plate and hardware. The cable(s) that connect the sensor(s) to the flow meter should be housed in conduit from the point at which the cable(s) exits the protective enclosure. Because turbulence can significantly influence flow reading accuracy, placement of the sensor is extremely important. Conveyance pipe segment connecting joints are typical generators of turbulence. Additionally, sensor cables should be secured in such a way as not to create turbulence. Once installed, flow accuracy can be determined by releasing a known quantity of water at varying rates through the conveyance and comparing actual volume released with the volume measured. An example of flow sensor installation in a pipe is shown in Figure 7-4.

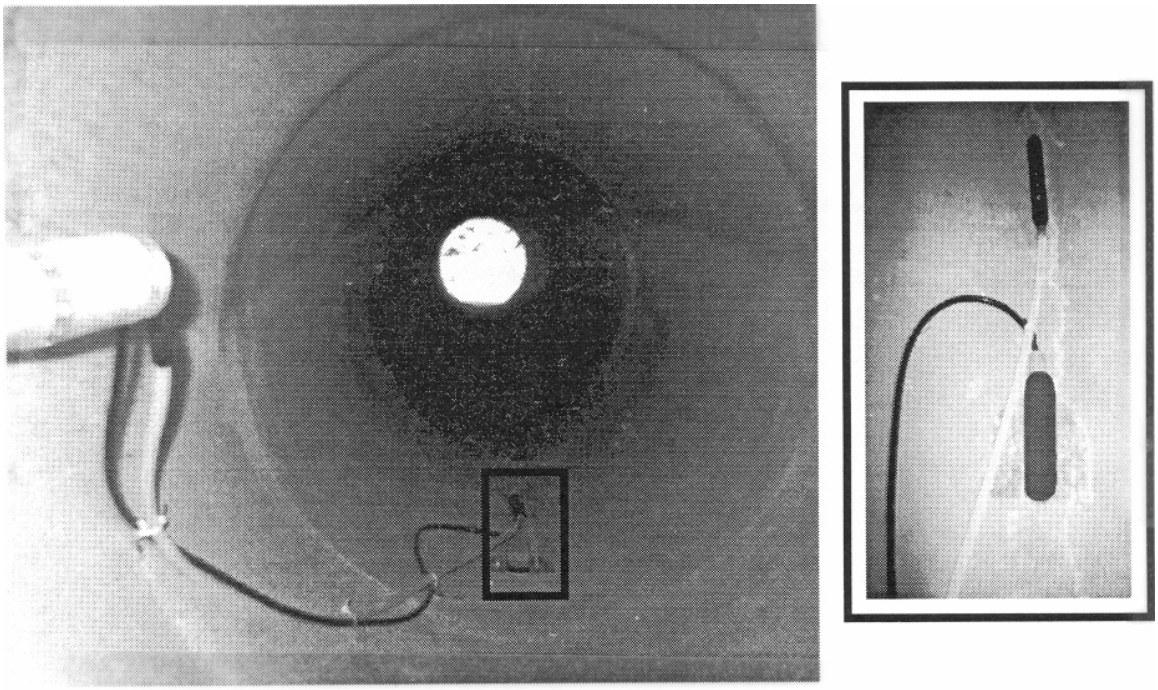


Figure 7-4. Flow Sensor Installation

Maintenance

The flow monitoring equipment should be calibrated according to manufacturer specifications. Flow meters typically contain desiccant packets and moisture indicators to keep the internal components of the equipment dry. The moisture indicators should be checked during each site visit, or at least once between each monitoring event. Often, system malfunctions can be attributed to high moisture levels inside the equipment. Any time a moisture indicator reads above the acceptable level, the desiccant should be replaced with new packets. At a minimum, the sensor(s) should be inspected and calibration checked prior to each monitoring event. The sensor(s) should be calibrated on an as-needed basis. The sensor cable(s) should be inspected at least prior to each stormwater monitoring season. All connections into the flow meter should be visually inspected prior to each monitoring event.

➢ AUTOMATED SAMPLER

The automated sample collection equipment should be installed and maintained according to manufacturer specifications. See ***Section 5*** regarding selection of automated equipment.

Installation

The automated sampler should be installed inside the protective enclosure in such a way that all controls, display windows and cable connections are easily accessed. All wiring should be secured, in a well organized fashion to the inside of the enclosure to prevent

accidental disconnection or damage. The sampler must be oriented in a way that will allow the sample intake tubing to enter the sampler without sharp bends or kinking, and to allow easy access for tubing replacement (see Figure 7-5).

At the sampler peristaltic pump, where the sample intake tubing is connected to the pump tubing, no metallic fittings or clamps should be used. Using "clean techniques" (***Appendix F***), the Teflon intake tubing should be inserted (at least a half inch) into the flexible pump tubing and fastened using a non-metallic clamp or cable tie. At no time during this procedure should the ends of the tubing be allowed to touch any object that is not known to be clean (see page 7-10). The flexible pump tubing should then be fed through the peristaltic pump and into the area of the sampler where the sample bottle(s) are housed (see Figure 7-6).

Adequate space must be available in the equipment enclosure to easily remove and replace sample bottles from the automatic sampler.

Proper placement of the sampler intake assures the collection of representative samples. The intake strainer should be placed in the main flow. The vertical position of the intake strainer in the flow is important. Placement at the bottom may result in excess heavy solids and no floating material, while placement at the top may result in excess floating material and no heavy solids. The constituents of interest must be considered when positioning the intake strainer. Placement of the intake strainer is usually at the channel invert, but may be mounted slightly above the invert on one side of the channel wall if high solids loadings are expected. This will reduce the amount of solids that may enter the intake strainer, and help prevent blockages. However, with the intake strainer offset above the channel invert, low flows may not adequately submerge the strainer, thus preventing sample collection.

Maintenance

Using laboratory provided blank water, the automated sampler should be calibrated according to manufacturer specifications to collect the desired sample aliquot. At a minimum, the calibration should be checked prior to each stormwater monitoring season. After each stormwater monitoring event, the sample bottle(s) should be checked to verify that the programmed sample volume was delivered to the sample bottle(s). If the programmed sample volume was not delivered accurately to the sample bottle(s), the automatic sampler should be recalibrated prior to the next monitoring event. Detailed information on the programming of automated equipment is presented in ***Section 9***.

Figure 7-5. Automated Sampler Installation

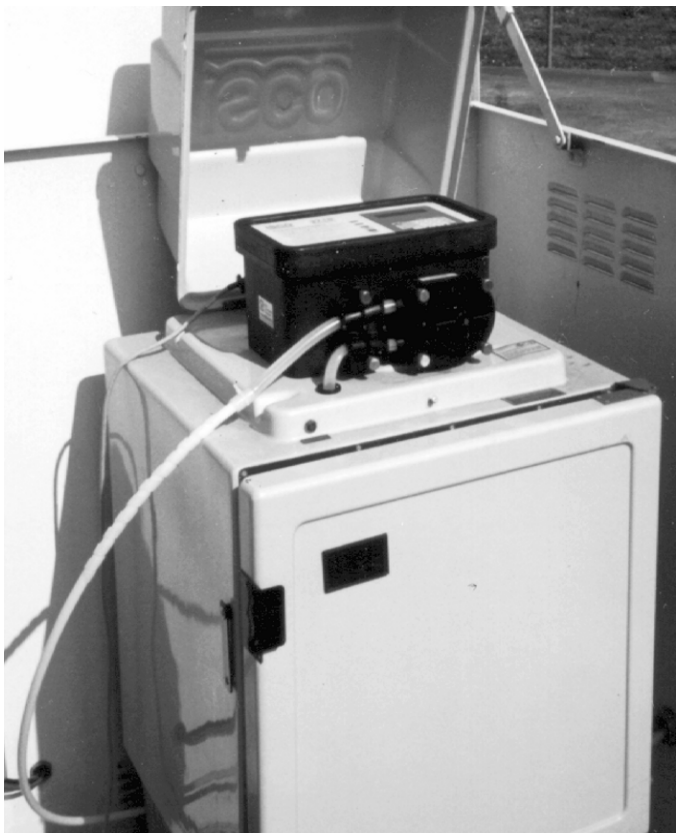


Figure 7-6. Pump Tubing Installation

➢ RAIN GAUGE

Rain gauges should be installed and maintained according to manufacturer specifications. Rain gauges must be installed in a secure fashion in a location where no buildings, trees, overpasses, or other objects obstruct or divert rainfall prior to entering the rain gauge. Additionally, rain gauges must be positioned so that they are level, and maintain that position throughout the study. If an electronic rain gauge is installed, all wiring should be housed in metal conduit from the gauge to the monitoring station enclosure. At a minimum, the rain gauge should be inspected, cleared of debris, and calibrated following manufacturer-specified procedure prior to each stormwater monitoring season. An example of an electronic rain gauge installation is presented in Figure 7-7.

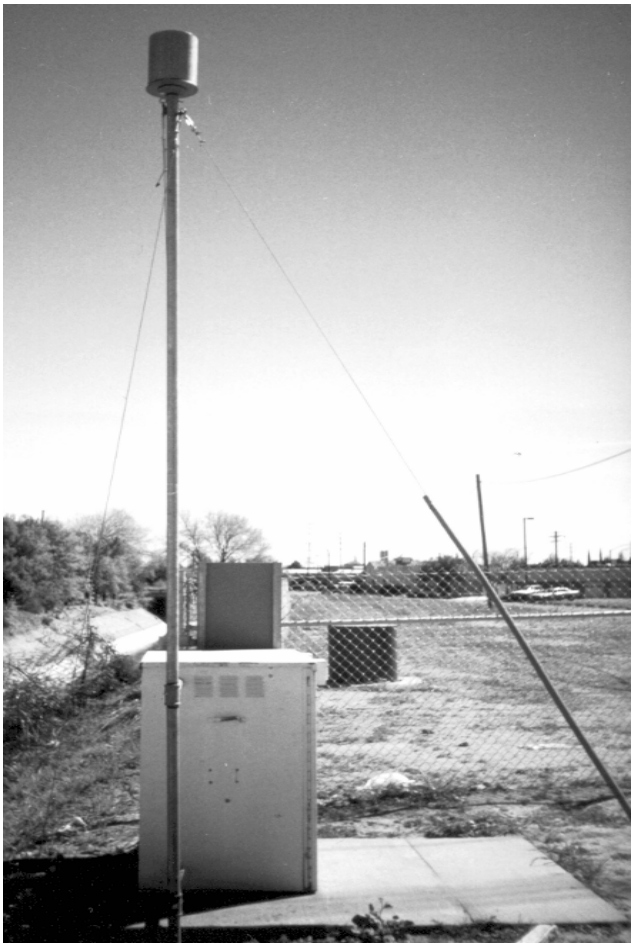


Figure 7-7. Rain Gauge

➢ CONFINED SPACE ENTRY

The installation and maintenance of stormwater monitoring devices often requires entry into designated confined spaces. At no time during storm conditions, or at any other time when significant flows are present, should any person enter a confined space. Any below-ground-level space that requires entry for equipment installation must be evaluated by personnel trained and certified in confined space entry. Only confined space certified personnel, with proper equipment and training, may enter a confined space. This holds true in the event of an accident. If an accident occurs, do not enter the confined space, but immediately request assistance from confined space certified personnel.

➢ BOTTLE AND EQUIPMENT CLEANING AND INSTALLATION

Prior to each stormwater monitoring event, sample bottles and sampling equipment should be cleaned and installed as specified in the following subsections.

Sample Bottle Cleaning

Prior to each stormwater monitoring event, clean sample bottles must be ordered from the analytical laboratory. Sample bottles must be prepared by the laboratory as specified by analytical method protocols. This includes the addition of sample preservatives where applicable. See Table 12-1 for specific bottle and preservative requirements. Sample preservation is discussed in more detail in ***Section 10***. Specific bottle cleaning procedures are presented in ***Appendix E***. Sample bottles should be stored in a clean environment with lids securely on until the time of use.

Composite Sample Bottle Installation

Clean composite sample bottles should be installed into automated sampling stations using "clean techniques" as described in ***Section 10*** and ***Appendix F***.

Sampling Equipment Cleaning

Any sampling equipment that comes in contact with the sample must be cleaned according to protocols presented in ***Appendix E***. Sampling equipment that most frequently comes in contact with the sample includes pump and sample intake tubing, intake strainers, composite bottle lids, and any grab sampling device, such as a bailer. After cleaning, each clean item should be individually double bagged (sealed in a plastic bag, then sealed in a second plastic bag) and stored until the time of installation or use. The plastic bags used for this purpose must be new and not previously used for any other purpose. Ziplock bags are ideal for this application and are available in a wide variety of sizes.

Sample Tubing and Intake Strainer Installation

Clean intake and pump tubing should be installed using "clean techniques", as described in ***Section 5***, ***10*** and ***Appendix F***, so as not to contaminate the tubing. The tubing should

remain double bagged until the time of installation. The clean tubing should have both ends covered with clean, non-metallic, non-contaminating material (i.e. polyethylene caps or clean latex gloves) until the intake strainer is installed at one end and a clean sample bottle is installed at the other end. The tubing ends should be covered with clean latex material to keep the tubing clean during installation, which typically involves feeding the tubing through protective conduit and pipelines. During installation, the intake and pump tubing should only be handled wearing clean, powder-free, nitrile gloves. During installation, the tubing ends should not touch any item not known to be clean. It is important to avoid kinking of the intake tubing during installation, as this will hinder sample collection.

Once the tubing has been installed, the intake strainer should be installed using "clean techniques". During installation, the strainer should only be handled while wearing clean, powder-free nitrile, gloves. The strainer should be attached to the end of the intake tubing and secured at the designated sampling location. All hardware in the immediate area of the intake strainer (hardware used to secure the suction tubing and intake strainer) must be stainless steel, polyethylene, or Teflon to minimize the possibility of contamination.

Sample Tubing Inspection

The sample intake and pump tubing should be inspected prior to each monitoring event. Intake tubing should be checked for kinks or cracks, and for adequate connection to pump tubing. Tubing clamps or cable ties, which secure the intake tubing to the pump tubing, should also be inspected prior to each monitoring event. Pump tubing should be checked for wear after each monitoring event. Pump tubing will show wear from the peristaltic sample pump. The frequency of pump tubing replacement will vary from site to site, depending primarily on head height, intake tubing length (may range from 3 to 99 feet), and temperature. If pump tubing wear is detected, the tubing should be replaced with new clean tubing prior to the next monitoring event.

SECTION 8
TRAINING

Familiarity with the requirements of the stormwater sampling and analysis plan (SAP), and competence in the techniques and protocols specified in the plan, are essential to ensure that stormwater samples are collected in a manner that meets the goals of the plan, while protecting the health and safety of the monitoring team members. This section briefly describes the training necessary to provide members of the stormwater monitoring team with the knowledge and skills to perform their assigned duties competently and safely.

Stormwater monitoring training should include the following basic elements:

KEY TOPICS

- **Review Sampling and Analysis Plan**
- **Review Health and Safety Plan**
- **Classroom Training Session**
- **Field Training/Sampling Simulation (Dry Run)**
- **Annual Refresher Training**

All stormwater sampling personnel must receive training prior to conducting any stormwater monitoring activities. Because storm sampling events are difficult to predict, and monitoring projects often run for a year or more, there is a good chance that one or more members of the sampling team may be unavailable to sample a given storm due to sick leave, vacation, etc. Thus, it is advisable to designate alternate sampling crew members who can fill in when primary members are unavailable. These alternate stormwater sampling team members should receive the same training as the primary members in the event that a primary team member is unavailable.

➢ REVIEW SAMPLING AND ANALYSIS PLAN & HEALTH AND SAFETY PLAN

All stormwater sampling team members and alternates should read the entire stormwater SAP to obtain the background information required for an overall understanding of the project. Including, project organization (event criteria, sampling frequency, etc.), responsibilities, monitoring sites, analytical constituents, field equipment installation and maintenance, monitoring preparation and logistics, sample collection, laboratory methods, QA/QC, data management, clean sampling techniques, and health and safety.

Team members should also read the health and safety plan, to become aware of the potential hazards associated with stormwater sampling, and become familiar with the methods to be employed to cope with those hazards.

➢ CLASSROOM TRAINING SESSION

A classroom-format training session should be held for all stormwater sampling team members and alternates to review the sampling techniques and protocols specified in the monitoring plan. Ideally, the training session should occur shortly before the expected onset of the wet season.

The following documentation should be reviewed thoroughly by training personnel during the preparation of a training session outline:

- Sampling and analysis plan,
- Health and safety plan,
- Monitoring equipment manuals, and
- Caltrans Guidance Manual: Stormwater Monitoring Protocols.

The training session should be organized in a chronological fashion, in order to follow the normal train of events from pre-monitoring preparations through post-monitoring activities. All standard operating procedures for the sampling equipment should be covered, along with the site-specific responsibilities of individual team members. In addition, any questions arising from the document review should be addressed during this session. An example of a basic classroom stormwater training session outline is shown in Figure 8-1.

Training personnel should circulate a copy of the SAP, health and safety plan, and all other appropriate documentation during the training session. The following is an example of items which should be on hand during a training session:

- Documentation (SAP, health and safety plan, equipment manuals, etc.),
- Storm kit and sampling supplies,
- Portable monitoring equipment and water (for demonstration purposes),
- Sample bottles and example bottle labels, and
- An example chain-of-custody form (similar to Figure 10-1).

Key sections of the SAP should be highlighted during the training session, and use of equipment should be demonstrated. To emphasize the importance of minimizing sample contamination, special attention should be given to proper sample handling techniques (See ***Appendix F*** for a description of clean sampling techniques). Ample opportunity should be provided to answer questions posed by field crew members.

1.0 Present an overview of the project
- 1.1 Driving force of the project
- 1.2 Project goals
- 1.3 Project duration
- 1.4 Sampling site locations

2.0 Responsibilities of everyone involved with the project

3.0 Weather tracking/storm selection

4.0 Station preparation and maintenance
- 4.1 Pre-storm site visits
- 4.2 Storm event site visits

5.0 Sample bottle ordering, labeling and preparation

6.0 Notification procedures
- 6.1 Storm action levels
- 6.2 Telephone tree

7.0 Sample collection
- 7.1 Sampling site safety
- 7.2 Traffic control
- 7.3 Clean sample handling protocols
- 7.4 Sampling equipment operation
- 7.5 Grab and composite sample collection procedures
- 7.6 QA/QC sample collection
- 7.7 Sample preservation

8.0 Demobilization of field crews
- 8.1 Demobilization decision
- 8.2 Station shut down
- 8.3 Sample compositing and splitting
- 8.4 Sample delivery (including holding time issues)
- 8.5 Chain-of-custody

9.0 Open discussion/questions and answers

Figure 8-1. Classroom Stormwater Training Session Outline

➢ FIELD TRAINING/SAMPLING SIMULATION

After the classroom training session, all sampling team members and alternates should attend a field training sampling simulation, or "dry run," under the supervision of the project manager or sampling team leader. The "dry run" should begin with a brief review of the classroom session. During the "dry run" sampling team members travel to their assigned sampling locations and run through the procedures specified in the Sample Collection section of the SAP, including:

- Site access and parking at the site,
- Traffic control measures (if any),
- Calibrating field equipment,
- Preparing the stations for monitoring,
- Taking field measurements,
- Collecting stormwater samples,
- Downloading data from automated equipment,
- Completing sample labels and field log forms,
- Packing samples, and
- Delivering or shipping samples to the laboratory.

All of the equipment and materials required for a wet weather sampling event should be mobilized and used to simulate, as closely as possible, the conditions of an actual sampling event. All stormwater monitoring team members (including alternates) should receive hands-on training with all field equipment and sample handling procedures. The project manager or sampling team leader should re-emphasize health and safety considerations during the field sampling simulation.

➢ ANNUAL REFRESHER TRAINING

For multi-year projects, an annual refresher training session should be held prior to the onset of each subsequent rainy season. In this session, all stormwater monitoring team members (including alternates) should review the monitoring plan and health and safety plan, with particular emphasis on those aspects for which individual members are responsible. The project manager or sampling team leader should provide more detailed instruction for any new team members, and, at his/her discretion, repeat the classroom training session and field sampling simulation (for example, if there are several new sampling team members).

SECTION 9
PREPARATION AND LOGISTICS

Adequate pre-storm preparations are essential for a successful stormwater monitoring event. Prior to deployment of field crews and the initiation of stormwater monitoring, it is imperative that weather systems are adequately tracked, field personnel are prepared, all necessary equipment is inventoried, and sample bottles are labeled.

Stormwater monitoring preparation and logistics should include the following basic elements:

KEY TOPICS

- **Weather Tracking**
- **Storm Selection Criteria**
- **Storm Action Levels**
- **Communications**
- **Ordering Sample Bottles**
- **Sample Bottle Labeling**
- **Field Equipment Preparations**
- **Mobilization of Field Crews**
- **Programming of Automated Equipment**

The above listed elements are discussed in this section.

➢ WEATHER TRACKING

It is recommended that project managers contract with a private weather forecasting service to provide custom forecast services on a weekly or semi-weekly basis, and to be available on an as-needed, on-call basis for telephone consultations regarding impending storm events. Reference for some California weather forecasting services are provided in ***Appendix G***. It is also valuable to maintain a computer modem capability to access National Weather Service (NWS) forecasts (www.nws.noaa.gov), as well as other weather information available through local ALERT systems and over the Internet. For example, hourly weather observations are available by modem from a network of surface weather monitoring stations throughout California. (See ***Appendix G*** for additional information regarding California meteorology and weather tracking). An example of a typical weather forecast printout is presented in ***Appendix G***.

Initially, at time periods of up to one week prior to arrival of a storm system, NWS model predictions and satellite imagery form the basis of the predictive information provided by NWS and private forecasters. As candidate storms approach, radar observations and

hourly reports from the land-based weather stations are used to track and evaluate storm progress. Telephone communication with a contract forecaster is an effective way to access current information from these sources. This information can be supplemented by weather news available on the Weather Channel and local television forecasts, as well as satellite imagery and other information available on the Internet. As rainfall becomes imminent, observations from local field personnel also can be useful.

A crucial role of the contract weather forecasting services is projection of a quantity of precipitation forecast (QPF) for an impending storm. This is the amount of precipitation (in inches) expected for the storm event, and is normally provided along with the expected duration of the storm. This information serves two essential purposes. First, it is necessary to determine, prior to making the decision to mobilize for a storm event, whether the storm will produce adequate runoff to permit collection of a meaningful set of samples. Second, because composite samples are typically collected on a flow-weighted basis, samples must be collected at appropriate intervals so as to not under-fill nor over-fill the composite bottles, based on the rainfall/runoff amounts expected during the course of the storm.

If a storm event QPF is over-predicted, and the actual rainfall amount falls far short of the prediction, there may not be enough sample collected during the course of the monitoring event to conduct the specified analyses. If the QPF under-predicts the amount of rainfall actually received, then the composite bottles may need to be replaced one or more times during the event, and if necessary the sampling frequency can be reduced at the time of such a bottle change.

During the wet season, when the stormwater monitoring program is active, the monitoring task manager or field coordinator continuously tracks weather conditions and potential storms. The frequency of weather tracking increases as incoming storms are identified as candidates for stormwater monitoring.

➢ STORM SELECTION CRITERIA

Specific storm selection criteria should be established to aid in the process of deciding whether or not to monitor an impending storm. The following are types of criteria which may be helpful when determining which storms to monitor:

- If the sampling plan allows, establish criteria that will allow monitoring of storms at different stages of the wet season, under a variety of antecedent conditions, and of varying duration, to characterize seasonal and hydrological variability. For example, it may be useful to monitor the first storm of the season (if practical) to account for constituent build up during the dry season, and then to follow up with additional monitoring events throughout the wet season.

- Establish a recommended minimum target storm event size for each site. A typical minimum QPF for stormwater monitoring is 0.25 to 0.50 inches of precipitation, although in some cases a minimum storm event size of 0.1 inches

may be appropriate. The make-up of a drainage area (size, slope, permeability) and the rainfall intensity will determine the amount of precipitation that must be delivered during any given storm before runoff begins. In areas with abundant rainfall, a minimum target storm event size of 0.5 inches of precipitation will help ensure that adequate runoff occurs for a successful monitoring event. In arid climates, smaller storms (such as 0.1 inches) may need to be targeted for sampling, to provide for an adequate number of monitoring opportunities.

- Identify any practical or logistical constraints on monitoring. These could include days of the week and hours during which monitoring can or cannot be conducted, holiday schedules, and competing personnel job responsibilities.

➢ STORM ACTION LEVELS

It is recommended that storm action levels be defined for the purpose of stormwater monitoring preparation, mobilization, and demobilization. An example of typical storm action levels is shown in Figure 9-1. All project management, field personnel, and laboratory personnel involved are notified each time there is a storm action level change.

➢ COMMUNICATIONS

A telephone tree should be developed to clearly define lines of communication and notification responsibilities. The telephone tree is used for stormwater monitoring preparation activities, personnel notification of storm action level changes, communications during stormwater monitoring, and coordinating demobilization activities following a monitored storm event. The telephone tree graphically shows the notification sequence from the project management personnel to field team leaders and finally to field personnel. The telephone tree should list laboratory personnel numbers for the purpose of after-hours sample delivery. Emergency telephone numbers should be listed, including numbers of hospitals nearest the monitoring stations. The telephone tree should include office, pager, cellular, home and any other pertinent telephone numbers for each person involved in the project. It is essential that each person listed on the telephone tree has access to a copy of the telephone tree at all times during the stormwater monitoring season. An example of a telephone tree is presented as Figure 9-2.

Action Level	*Condition*	*Action*
Non-monitoring	Not actively seeking candidate storms	*Task Manager*: • Monitor weather reports weekly *Field Crews*: • No impact on activities
Standby	Evaluating developing storm systems	*Task Manager*: • Monitor weather reports semi-weekly *Field Crews*: • Notify Project Manager where you will be and how you can be reached if you leave the area for more than one or two days • Arrange for substitute if needed
Pre-Alert	Target storm expected within the next 72 hours	*Task Manager*: • Monitor weather reports every 24 hours • Verify operation of monitoring equipment as needed • Alert field crews regarding change in action level • Verify availability of field crew *Field Crews*: • Remain in local area if possible • Verify availability with Project Manager
Alert	Target storm expected within the next 24 hours	*Task Manager*: • Monitor weather reports every 6 hours • Alert field crews regarding change in action level and probable time of storm • Alert analytical laboratory *Field Crews*: • Prepare monitoring equipment for sampling
Go	Precipitation is imminent or has begun on targeted storm	*Task Manager*: • Monitor weather reports as needed • Mobilize field crews *Field Crew*: • Mobilize to sample collection stations
Post-Storm	Precipitation ceased or desired storm duration reached	*Task Manager*: • Demobilize field crews *Field Crew*: • Split composite samples for field duplicates • Ensure timely delivery of samples to analytical laboratory • Complete field notes • Prepare for next storm - inventory/clean/organize/replace equipment as necessary *Laboratory* • Analyze samples

Figure 9-1. Storm Action Levels

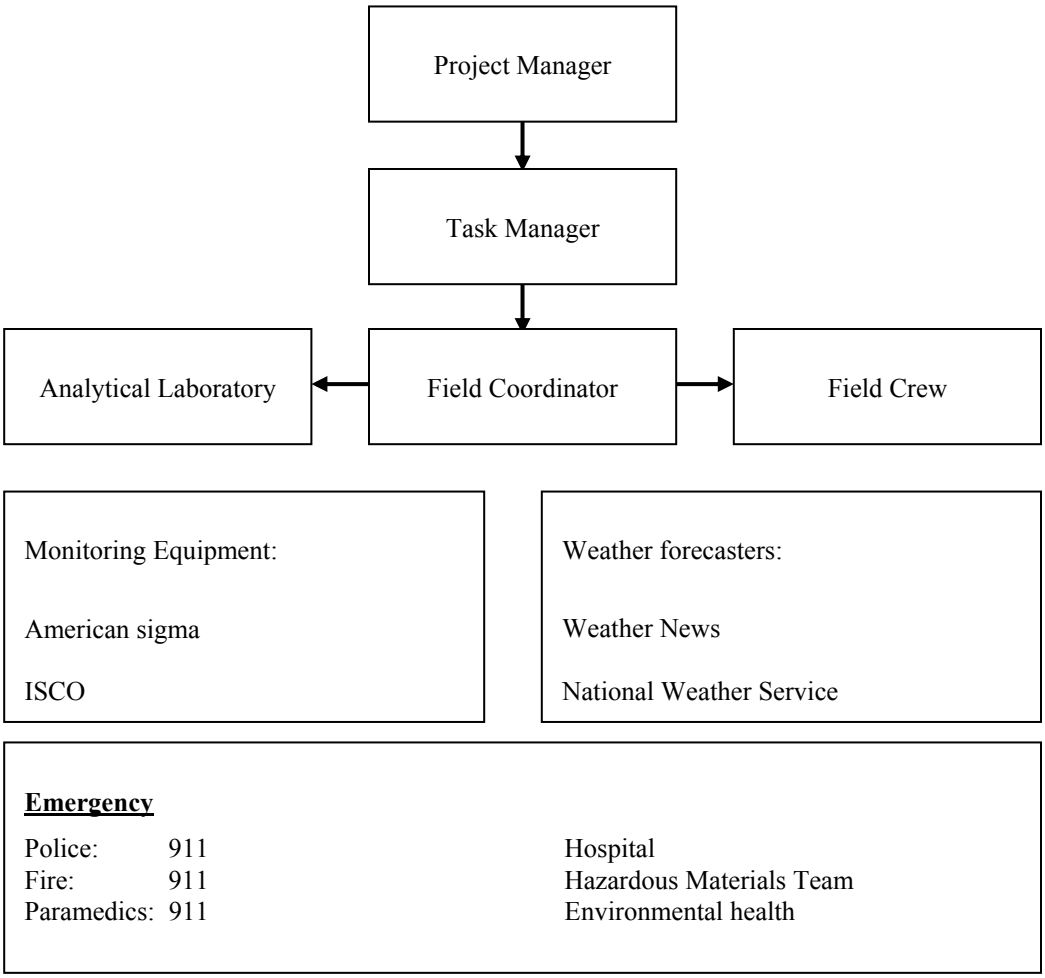


Figure 9-2. Telephone Tree Example

➢ ORDERING SAMPLE BOTTLES

Prior to the first targeted storm of each monitoring season a sample bottle order is placed with the analytical laboratory. Enough bottles should be ordered for multiple events so as to have plenty of bottles on hand. Immediately following each monitoring event, the bottle inventory should be checked and additional bottles ordered as needed. Bottles are ordered for all planned stormwater samples, including quality control samples. The bottle order should also include blank water for the collection of required field blank samples. See ***Section 11*** for QA/QC sample collection guidance. The bottles must be the proper size and material, and contain preservatives as appropriate for the specified laboratory analytical methods (***Section 12***). Additional bottles should be ordered in case of accidental breakage or contamination.

Composite bottles must be pre-cleaned according to the procedures specified in ***Appendix E***. Field crews must inventory sample bottles upon receipt from the laboratory

to assure that adequate bottles have been provided to account for the analytical requirements of all composite and grab samples.

➢ SAMPLE BOTTLE LABELING

All sample bottles should be pre-labeled to the extent possible before each stormwater monitoring event. Pre-labeling sample bottles simplifies field activities, leaving only date, time, sample number, and sampling personnel names to be filled out in the field. Basic water-proof bottle labels are available pre-printed with space to pre-label by hand writing or typing. Custom bottle labels may be produced using blank water-proof labels and labeling software. A standardized bottle label should include the following information, with other items as appropriate:

- Project Name
- Station Name
- Event Number
- Date and Time
- Sample Type (grab or composite)
- Bottle __ of __ (for multi-bottle samples)
- Collected by:
- Preservative, and
- Analysis

Since field blank and field duplicate samples are typically sent to the analytical laboratory "blind", bottle labels for these QA/QC samples should be completed with pseudonym site names. Actual QA/QC sample collection site information must be carefully noted in the field log. See ***Section 11*** for detailed QA/QC sample information.

Bottles should be labeled in a dry environment prior to field crew mobilization. Attempting to apply labels to sample bottles after filling will cause problems, as labels usually do not adhere to wet bottles. The labels should be applied to the bottles rather than to the caps. An example of a typical bottle label is shown below as Figure 9-3. See ***Section 12*** for required sample bottle types and preservatives.

Project:	Stormwater Quality Monitoring Program		
Station:	Neal Road	Event:	Event #1
Date:	**12/15/98**	Time:	**0300**
Sample Type:	**X** Grab _ Composite	Bottle:	**1** of **2**
Preservative:	Sodium thiosulfate	Collected By:	**John Smith**
Analysis:	Fecal Coliform		

Figure 9-3. Typical Sample Bottle Label Example

Computer labeling programs can save a great deal of time in generating bottle labels. The sites and analytical constituent information can be entered in the computer program for each monitoring program in advance, and printed as needed prior to each monitoring event.

➢ FIELD EQUIPMENT PREPARATION

Prior to the first targeted storm event of each monitoring season, and immediately after each monitored event, the field crews will inventory, restock, replace, clean, calibrate, maintain, and test field equipment as needed. Field equipment is inventoried using a comprehensive checklist of all required field equipment (tools, sample bottles, flashlights, extra batteries, safety equipment, first-aid kit, cellular telephone, etc.). Field equipment should be kept in one location which is used as a staging area to simplify field crew mobilization. An example field equipment checklist is provided as Figure 9-4.

The following equipment preparation procedures should be conducted prior to each targeted storm:

- Inspect the pump tubing and replace if necessary,
- Inspect intake tubing condition and connections,
- Inspect desiccant cartridges in sampler and flow meter,
- Inspect rain gauge for blockage,
- Check all electrical connections,
- Ensure that batteries are adequately charged and positioned,
- Insert sample bottles into sampler (see ***Section 10*** and ***Appendix F*** for detailed bottle changing procedures),
- Place ice around sample bottle in non-refrigerated samplers,
- Reset automatic sampler, and

- Calibrate any portable analytical meters that will be used to make field measurements.

At a minimum, the frequency and nature of equipment maintenance for all field equipment should be consistent with the manufacturer's recommendations.

➢ MOBILIZATION OF FIELD CREWS

When a potentially acceptable storm is approaching (i.e., the storm meets the storm selection criteria, as discussed previously in this section), the field crew and analytical laboratory will be alerted by the monitoring task manager. Field crews will be given notice to mobilize when precipitation is imminent or has begun.

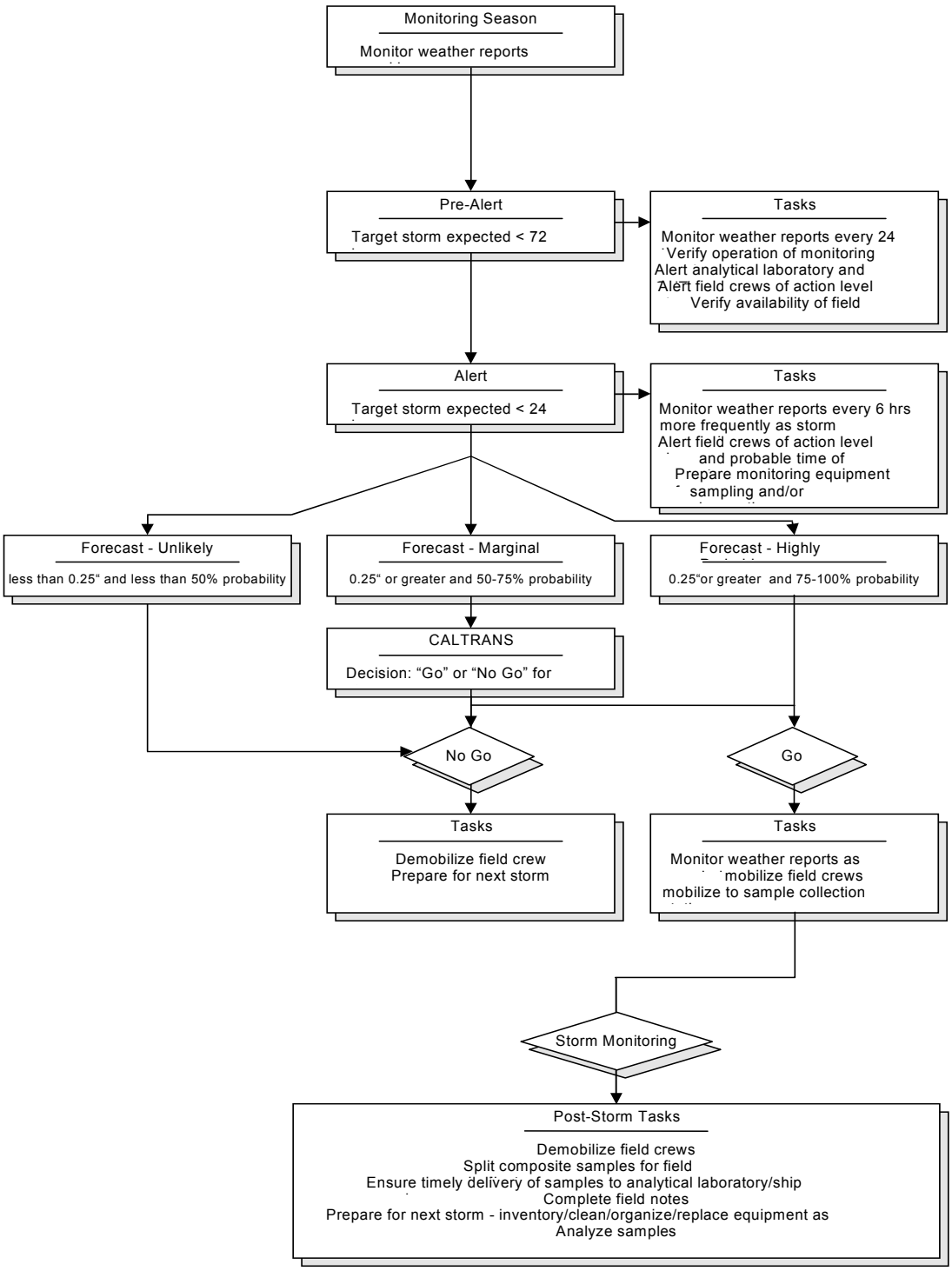
Establishing deployment criteria is recommended for the purpose of standardizing field crew mobilization. A flow chart that combines project specific storm selection criteria (i.e., antecedent conditions, storm size, storm duration) with storm action levels (Figure 9-1) can be useful for standardizing field crew mobilization for a given project. An example of a typical deployment flow chart is presented as Figure 9-5.

When first alerted, field crew members should consult their sampling plan and check monitoring equipment and supplies to ensure they are ready to conduct monitoring. Once given the go-ahead by the monitoring task manager, the field crew members will travel to their assigned locations and conduct final preparations for monitoring. Upon arrival at the monitoring site, the field crew should:

- Check battery levels,
- Check tubing and all connections,
- Install clean composite bottle(s) and remove lid(s) as necessary (see ***Section 10*** and ***Appendix F*** for detailed bottle changing procedures),
- Add ice to sampler if necessary, and
- Program automatic flow meter and sampler.

Storm Kit Equipment List	Storm Mobilization Equipment List
☐ First aid kit	☐ Storm kit
☐ Keys (to gates and to enclosures)	☐ Waterproof log books/log sheets
☐ Flashlights (2) - hand held and head mounted	☐ Paper towels
☐ Maps	☐ D.I. water squirt bottles
☐ Large flat screwdriver	☐ Ice scoop
☐ Small flat screwdriver	☐ Chain of custody forms
☐ Umbrella - large size	☐ Appropriate number of composite bottles with mesh carriers and buckets
☐ Alkaline batteries for flashlights	☐ Appropriate number of grab sample bottles
☐ Write in the rain" pens (2), waterproof markers-fine point (2)	☐ Bottle labels
☐ Spare sample bottle labels	☐ Coolers and ice
☐ Desiccant (for samplers and flow meters)	☐ Grab pole, rope and duct tape
☐ Diagonal cutters	☐ Laboratory-provided blank water
☐ Electrical tape	☐ Cellular phone
☐ Cable ties (assorted sizes)	☐ Personal extra change of clothes
☐ Utility knife	☐ Lighting
☐ Zip-lock baggies (assorted sizes)	☐ Personal rain gear
☐ Gloves - powder free nitrile	☐ Hard hats and orange safety vests
☐ Duct tape	☐ Traffic cones/signs
☐ Rubber bands	☐ Sampling Plan/Health and Safety Plan

Figure 9-4. Field Equipment Checklist



Note: Specific precipitation levels, etc. presented in this example are project specific.

Figure 9-5. Example Deployment Flow Chart

If sample collection is conducted at a station without a refrigerated sampler, or if grab samples are required, the field crew will need to obtain ice (for sample preservation) on the way to the sampling station. Composite sample bottles are required to be kept in a refrigerated sampler, or surrounded with ice during sample collection. Ice for grab samples should be kept in ice chests where full grab sample bottles will be placed. Keeping ice in double zip-lock bags facilitates clean easy ice handling. Refreezable ice packets are generally not recommended because they are susceptible to leakage.

➢ PROGRAMMING OF AUTOMATED EQUIPMENT

The steps involved will vary depending upon the software programs selected; however, the following steps illustrate what is generally involved when a stormwater monitoring event is anticipated:

- System counters (precipitation, runoff volume, sample count, etc.) are reset to zero,
- The mode is switched from non-monitoring mode to monitoring mode. This typically will increase data collection frequency and allow the system to begin sample collection once thresholds are met,
- Thresholds are set for all sampling locations to allow stations to enter sample collection mode. Thresholds can include the minimum precipitation amount, flow depth, or flow volume required to initiate the sample collection routine,
- For flow paced sampling, the flow volume per sample (i.e., the flow volume that passes between each composite aliquot collected) is set based on the expected amount of rainfall and runoff,
- The system should have "start sampling" and "stop sampling" options that can be selected when appropriate (e.g., at the beginning of a storm, during bottle changes, at the end of a storm),
- When all samples have been collected, the sampling event is terminated and software is switched back to the non-monitoring mode, and
- Data are downloaded from the data logger to a personal computer (PC) immediately following the storm event.

Most automated monitoring stations typically contain continuous flow measurement devices and data logging software. To collect flow-proportioned composite samples, the flow measurement device must be programmed to send a pulse to the sampler each time a specified flow volume has passed the flow sensor. The sampler, in turn, is programmed to collect a sample each time it receives a pulse. Therefore, each time the programmed flow volume per sample has passed the sampling location, a composite sample aliquot is collected.

To insure the collection of representative samples, automatic samplers should be programmed to perform a full back purge cycle between each sample aliquot collected.

When multiple sample containers are used, samplers should be programmed to perform a full back purge cycle prior to the filling of each individual container. Purging the sample intake tube prior to the collection of each aliquot or individual container sample helps to keep the line clear. Debris at sample tubing intake may cause flow restriction, which reduces velocities within the intake tube. When intake tube velocities are reduced heavy particulates may not adequately represented in the sample. Additionally, reduced velocities may result in sampler aliquot volume calibration problems, or increased pump tubing wear. Automatic samplers may also be programmed to perform rinse cycles after the back purge cycle and prior to the collection of sample aliquots. However, for stations that have a high sampling head height or a long intake tubing length, rinse cycles are not advised because of additional wear on the pump tubing. Worn or split pump tubing will result in missed sample aliquots.

The flow volume per sample (the amount of flow that passes the sampling point between each aliquot collected) must be programmed into the flow meter in proportion to the predicted rainfall amount for each storm event, to set the sample pacing so as to fill the composite bottle(s) at an appropriate rate.

Calculation of the flow volume per sample is performed using the predicted rainfall amount (quantity of precipitation forecast, or QPF), the known or estimated drainage area, and the composite runoff coefficient for the area monitored to calculate the expected runoff flow volume for the storm event. Flow volume per sample can be determined using the formula presented below:

$$V_r\,(acre-feet) = QPF\,(inches) * \frac{1\,(ft)}{12\,(inches)} * A\,(acres) * C$$

$$V_r\,(cf) = V_r\,(acre-feet) * \frac{43{,}560\,(cf)}{1\,(acre-foot)}$$

$$V_s\,(cf) = \frac{V_r\,(cf)}{CSA}$$

QPF = quantity of precipitation forecast
A = drainage area
C = runoff coefficient
V_r = total runoff volume for forecast storm (calculated)
CSA = number of composite sample aliquots required for complete composite
V_s = flow volume per sample

Example:

0.33 inches = QPF (quantity of precipitation forecast)
150 acres = A (drainage area)
0.6 = C (runoff coefficient)
20 = CSA (number of composite sample aliquots required for complete composite)

$$V_r\ (acre-feet) = 0.33\,(inches) * \frac{1\,(ft.)}{12\,(inches)} * 150\ (acres) * 0.6 = 2.475\,(acre-feet)$$

$$V_r\ (cf) = 2.475\,(acre-feet) * \frac{43,560\,(cf)}{1\,(acre-foot)} = 107,811\,(cf)$$

$$V_s\ (cf) = \frac{107,811\,(cf)}{20\,(aliquots)} = 5,391\,(cf/aliquot)$$

The flow volume per sample is calculated so that if the predicted precipitation is delivered by the targeted storm, the automatic sampler will collect enough samples to conduct the set of analytical measurements specified in the sampling plan, plus any required QA/QC analyses. If the required analytical volume is less than the capacity of the composite bottle(s), then a margin of safety can be provided by setting the sample pacing to collect the needed composite sample volume at some fraction (typically one half to three quarters) of the predicted rainfall amount. This is done by using an appropriate fraction of the QPF in calculating the flow volume per sample. If less rainfall is received than predicted by the QPF, this may allow for collection of an adequate composite volume during the storm event.

The automatic sampler is programmed to collect a specific number of composite sample aliquots of specific volume before halting the sampling program, so as to fill the composite bottle(s) to the desired level, without overfilling (see ***Section 10***, Table 10-1 for minimum acceptable number of aliquots required to meet monitoring event representativeness requirements).

The number of composite sample aliquots ("CSA") used in the above equation may be determined based on total composite sample volume required and the desired sample aliquot volume. An adequate number of sample aliquots should be collected to produce a composite sample that is representative of the runoff for the entire sampling event. The total sample volume required for the laboratory to conduct all planned analyses, including QA/QC analyses, may be divided by the selected sample aliquot volume to produce the required sample aliquot number.

Because automated samplers tend to exhibit slight variations in aliquot volume delivered, it is recommended that the sample aliquot volume be a minimum of 200 milliliters. A typical sample aliquot volume is 500 milliliters. If 10 liters of composite sample volume is required to perform the specified laboratory analyses, then 20 composite sample aliquots would be required for a complete composite sample, at a sample aliquot volume of 500 milliliters. The input value used for the CSA variable would therefore be 20.

The runoff coefficient for a specific drainage area is defined as the fraction of total precipitation volume delivered to the area that ends up as stormwater runoff at the point of discharge. Runoff coefficients may be available from Caltrans District personnel or from local flood control or public works agencies. If not, the coefficient may initially be estimated to correspond to the fraction of impervious area within the drainage area. Or, if the pervious and impervious areas are known in a drainage area, it may be useful to modify the above equation to include separate runoff coefficients for pervious and impervious areas as follows:

$$V_r\,(acre-ft) = QPF\,(in.) * \frac{1\,(ft)}{12\,(in.)} * \left[\left(A_{pervious} * C_{pervious}\right) + \left(A_{impervious} * C_{impervious}\right)\right]$$

The number of sample aliquots per composite and the sample aliquot volume, once determined, are typically programmed into the automatic sampler. The CSA is used in the above equation throughout the monitoring season.

The flow volume per sample calculation normally requires input of only one variable for each storm event (the QPF), once the equations are set up for each monitoring station.

If a storm delivers more precipitation than expected, composite bottle replacement may be required to capture runoff from the entire storm event. ***Section 10*** describes composite bottle replacement procedures.

If less precipitation is received than predicted, the resulting composite sample volume may be insufficient to conduct all planned analyses. It may be possible to salvage a successful monitoring event in such cases by reducing the planned QA/QC analyses, or by eliminating some analytes while retaining others. Metals, for example, are key stormwater constituents which require relatively small sample volumes for analysis. To make well-informed decisions, the monitoring task manager should be familiar with the minimum sample volumes necessary to conduct each type of analysis (see ***Section 12***), as well as the overall goals and priorities of the monitoring program.

After one or two storms have been monitored, the flow volume per sample formula for each monitoring site should be checked for accuracy. To check the formula, the actual measured storm event precipitation should be plugged into the formula as the quantity of precipitation forecast (QPF). Then the resulting calculated total runoff volume (V_r) should be compared to the actual measured storm event total runoff volume. The formula may then be modified, if necessary, by modifying the runoff coefficient (C). Keep in mind that there will naturally be some variability from storm to storm at any given site because of non-uniform rainfall intensity throughout the drainage area and soil saturation (for sites with a significant pervious surfaces).

SECTION 10
SAMPLE COLLECTION

Equipment and bottles used in the collection of samples to be analyzed for trace metals, trace organics, nutrients, and bacteriological constituents must be handled with great care to minimize the possibility of contamination. The ease with which stormwater samples can be unintentionally contaminated cannot be overemphasized. The following procedures include sample handling techniques that maximize the ability of sampling personnel to collect samples reliably and with minimal sample contamination.

The following are basic sample collection and handling elements required during stormwater monitoring:

KEY TOPICS

- **Personnel Safety**
- **Sampling Equipment and Bottles**
- **Clean Sampling Techniques**
- **Grab Sample Collection**
- **Composite Sample Collection**
- **Flow Monitoring**
- **Composite Bottle Changing**
- **Sample Representativeness Evaluation**
- **Multi-Bottle Compositing, and Composite Sample Splitting**
- **Sample Preservation**
- **Sample Filtration**
- **Sample Delivery/Chain of Custody**

These elements are described below to provide sample collection and handling guidance for field personnel engaged in stormwater monitoring.

➢ PERSONNEL SAFETY

Before stormwater samples are collected, personnel must ensure the safety of such activities at each sampling location. As mentioned in ***Section 3***, personnel safety should be considered when selecting monitoring sites. Adherence to the following recommendations will minimize risks to sampling personnel:

- At no time during storm conditions or when significant flows are present should sampling personnel enter a manhole or standpipe.

- Two-person field crews should be available for all field work to be conducted under adverse weather conditions, or whenever there are risks to personal safety.
- Use of automated samplers can eliminate many of the hazards associated with manual sample collection, as personnel are not required to be at the site for composite sampling.
- Personnel must be trained regarding appropriate traffic control measures. If appropriate, a traffic control plan should be developed for each site and included in the sampling plan and analysis plan prior to conducting sampling events.
- Only personnel properly trained and equipped for confined space entry may enter a space designated as "confined".
- When appropriate, an encroachment permit must be filed with the district.

➢ SAMPLING EQUIPMENT AND BOTTLES

Generally, field personnel are responsible for collecting composite samples and/or grab samples. It is important to use the appropriate sample bottles and equipment for each parameter to be measured (see ***Section 5***). Improper bottles and equipment can introduce contaminants and cause other errors which can invalidate the data. For example, chemicals may leach from the bottle into the sample, or waterborne constituents may cling to sampling equipment or to the sides of the bottle.

As general guidelines, all sampling equipment and sample bottles used for trace metals determination must be nonmetallic and free from any material that may contain metals. Only high density plastic or Teflon containers should be used for metals analytical sample storage bottles. All sampling equipment and sample bottles used for trace organics determination must be glass or Teflon. Borosilicate glass is acceptable for composite sample containers because it is considered an acceptable compromise for collection of stormwater samples that will be analyzed for both metals and organic compounds. Nutrients and most "conventional" parameters may be sampled using plastic or glass bottles.

The size and type of sample composite sample bottle(s) will depend on the analyses selected. Composite sample bottle(s) must hold sufficient volume to provide the analytical laboratory with enough sample volume to conduct all of the selected analyses, plus any QA/QC requirements. The bottle type also must be appropriate for all planned analytical constituents. When composite samples are to be analyzed for both metals and organics, for example, the composite bottle(s) must be borosilicate glass or Teflon.

Certain constituents cannot be analyzed from composite bottles, and must be collected as "grab" samples. For example, all sampling equipment and sample bottles used for bacteriological determinations must be sterile. This normally requires field collection of

the sample directly into the sterile "bacti" bottle, or use of a sterile Teflon bailer as an intermediate device. Samples for oil & grease or petroleum hydrocarbons analysis must be collected directly into the glass bottle that the laboratory will use for analyses, because the use of any intermediate container or tubing may result in some loss of the material being analyzed. Other analytes, such as ammonia and volatile organic compounds, must be collected as grab samples because of the risk of losing the constituent(s) to volatilization in a composite bottle. ***Section 12*** provides information on the appropriate bottles for specific constituents and analytical methods.

Before samples are collected, all sampling equipment and bottles are cleaned in a laboratory using appropriate detergent, mineral acids, and deionized water as described in ***Appendix E***. The laboratory is responsible for generating acceptable equipment blanks and sample bottle blanks to demonstrate that the sampling equipment and bottles are free from trace metals and organics contamination before they are delivered to field sampling personnel. An acceptable blank is one that is free from contamination below the minimum level specified in the referenced analytical method. ***Section 11*** provides additional information on collection of equipment blanks.

After cleaning, sample bottles and laboratory-cleaned sampling equipment are handled only while wearing clean, powder-free nitrile gloves. All laboratory-cleaned sampling equipment and metals analysis storage bottles are double bagged in clean zip-lock plastic bags for storage or shipment. Clean bottles are stored in a clean area with lids properly secured.

Immediately prior to the filling of grab sample bottles, the bottle labels should be checked, and date and time added using a waterproof pen (see ***Section 9*** for sample bottle labeling). Attempting to label grab sample bottles after sample collection may be difficult because of wet labels.

➢ CLEAN SAMPLING TECHNIQUES

Caltrans stormwater monitoring projects employ "clean" sampling techniques to minimize potential sources of sample contamination, particularly from trace pollutants. Experience has shown that when clean sampling techniques are used, detected concentrations of constituents tend to be lower. Clean sample collection techniques that should be followed during the collection of stormwater samples are described below. More extensive clean sampling techniques may be required under certain conditions, such as monitoring to assess receiving water impacts. See ***Appendix F*** for a detailed description of more extensive clean sampling techniques.

Extreme care must be taken during all sampling operations to minimize exposure of the samples to human, atmospheric, and other potential sources of contamination. Care must be taken to avoid contamination whenever handling composite bottles, lids, sample tubing, and strainers. Whenever possible, grab samples should be collected by opening, filling and capping the sample bottle while submerged, to minimize exposure to airborne

particulate matter. Additionally, whenever possible, samples should be collected upstream and upwind of sampling personnel to minimize introduction of contaminants.

To reduce potential contamination, sample collection personnel must adhere to the following rules while collecting storm water samples:

- No smoking.
- Never sample near a running vehicle. Do not park vehicles in immediate sample collection area (even non-running vehicles).
- Always wear clean, powder-free nitrile gloves when handling composite bottles, lids, sterile grab sample bottles, tubing or strainers.
- Never touch the inside surface of a sample bottle or lid, even with gloved hands.
- Never touch the exposed end of a sampling tube.
- Never allow the inner surface of a sample bottle, lid, or sampling tube to be contacted by any material other than the sample water.
- Never allow any object or material to fall into or contact the collected sample water.
- Avoid allowing rain water to drip from rain gear or other surfaces into sample bottles.
- Do not eat or drink during sample collection.
- Do not breathe, sneeze or cough in the direction of an open sample bottle.

➢ GRAB SAMPLE COLLECTION

Grab sampling is required for monitoring parameters that transform rapidly, require special preservation, or adhere to bottles. For example, samples to be analyzed for oil and grease, petroleum hydrocarbons, ammonia, volatile organics, and bacteria are required to be collected as grab samples only.

When grab samples are only collected once during a storm event, it is important to collect those samples under flow conditions that will provide the most representative sample possible. In an attempt to provide grab samples representative of an entire storm event, to the greatest extent possible, grab samples should be collected during event peak flow. However, peak flow conditions are typically difficult to determine during a monitoring event. Therefore, grab samples should be collected using best professional judgement, during the estimated midpoint of a monitoring event, under moderate (not low) runoff flow conditions.

Grab samples are typically collected by direct submersion of each individual sample container. It is acceptable for some grab samples to be collected using intermediate containers and for some (e.g., oil and grease, petroleum hydrocarbons) it is not. When use of an intermediate container is appropriate (e.g., for ammonia, volatile organics), grab samples should be collected by holding an appropriate container (bucket, bailer, sample bottle, etc.) under the outfall of a discharge pipe, at the lip of an inlet grate, or by dipping a container downstream of a discharge with the container opening facing upstream, depending on monitoring site configuration. The sample is then poured immediately into the appropriate grab sample bottle. Samples for bacteriological analysis must be collected in sterile containers. Sterile Teflon bailers are available for this purpose; otherwise, the sample must be collected directly into the sterile "bacti" bottle. Clean techniques must be used when collecting bacteriological samples.

When collecting samples for oil and grease or petroleum hydrocarbon analysis, the sample must be collected directly into the bottle that will be used in the laboratory, because petroleum-derived compounds may adhere to the sample container (the laboratory analyzes samples for these constituents by extracting the entire contents of the sample bottle). Because oil and grease and other petroleum hydrocarbons tend to float, these grab samples should be collected so as to include sampling of the air/water interface.

➢ COMPOSITE SAMPLE COLLECTION

A composite sample is made up of multiple sub-samples (aliquots) collected over some spatial or temporal range. Stormwater runoff composite samples are typically collected from a single location during a period of runoff. Such temporal composites can be collected on a time-proportioned basis (equal sample aliquot volumes collected at equal time intervals) or flow-proportioned basis (samples are collected either on an even-time-interval basis, with sample aliquot size proportional to instantaneous measured flow rate, or on an even-flow-interval basis, with a set aliquot volume collected at passage of each equal, pre-set flow volume). Because stormwater runoff flow typically varies throughout a storm event, flow-proportioned composite sampling is the standard composite sample collection method (see ***Section 5*** for guidance on the selection of sample collection methods and equipment). Composite samples are typically collected using automated sampling equipment, but can also be collected manually.

Flow-proportional sampling requires determination of several key parameters:

- Storm event quantity of precipitation forecast ("QPF"; from forecast information),
- Expected runoff volume (determined from the QPF and watershed characteristics),
- Expected storm duration (for even-time-interval methods),

- Minimum required composite sample volume for all planned analyses (see ***Section 12***obtained from contract laboratories),
- Minimum acceptable number of sample aliquots (see Table 10-1 and discussion below), and
- Sample aliquot size (varies proportional to measured flow throughout the event for even-time-interval methods, and set to a single volume per event for even-flow-volume methods)

See ***Section 9*** for a detailed discussion of how to program flow-proportioning parameters.

Automated Composite Sample Collection

Automated flow-proportional composite sampling is typically done on an even flow-volume-per-sample basis; that is, a sample aliquot of equal size is collected every time a pre-selected flow volume passes by the flow sensor. The flow volume per sample is determined based on the quantity of precipitation forecast (QPF) and the required composite sample volume (see ***Section 9***), with consideration of the minimum required number of sample aliquots for the storm event (see Table 10-1 and discussion below). At automated monitoring stations, sample collection will begin automatically once the programmed thresholds (triggers) have been met (see ***Section 9*** for automated station programming and preparation).

Automatic sampling stations should be checked periodically throughout a monitored storm event to make sure the station is function properly. If the composite sample bottle (or bottles, in the case of multi-bottle composite sample collection) fills more rapidly than expected, field personnel should be mobilized to conduct a bottle change (bottle changing is described in detail later in this section). If the composite sample collection period exceeds 24 hours, the composite sample bottle(s) should be replaced with (a) clean bottle(s) at or prior to the end of each 24-hour period. For constituents with short holding times, such as 48 hours or less, composite sample volume should be removed from each 24-hour composite for analysis as necessary to comply with holding time requirements.

After the storm event has ended, field personnel are mobilized to retrieve the full composite sample bottle(s) and interrogate sampling equipment. Sample splitting and delivery to the laboratory are described later in this section.

Manual Composite Sample Collection

Manual composite sample collection may be conducted at monitoring sites that are not equipped with automatic equipment. Manual composite sample collection can be done on a time-proportional compositing basis, but it is generally possible to perform flow-proportional manual composite sampling using one of the techniques described below. Manual flow-proportional composite sample collection is conducted using the same basic

principals as automatic composite sample collection. Typical manual composite sample collection methods are described below.

Flow-Proportioning – Even Time Interval Basis

This method involves the collection of sample aliquots at a specified time interval, with the aliquot volume set proportional to the measured flow rate. The sampling time interval is set to ensure collection of the minimum number of aliquots required for adequate storm representativeness (see discussion later in this section), based on the expected (forecast) storm duration. Sample aliquot volumes are set to ensure collection of the required composite volume over the course of the expected storm event, based on the storm QPF and the expected runoff volume (this requires some advance knowledge of rainfall/runoff relationships in the monitored watersheds; see ***Section 9*** for a discussion of the relevant calculations). At each sampling interval the flow rate is measured (using one of the methods described in ***Section 5***), and a sample aliquot volume is collected in proportion to the measured flow prior to collection. Sample aliquots are composited to generate a single event composite sample. This method requires advance preparation of a table showing the aliquot volumes to collect for a range of expected flow rates, over a range of possible storm event QPFs. In this table, the aliquot volumes are set so as to ensure collection of the full composite sample volume required to perform all planned analyses for a given QPF.

Flow-Proportioning – Even Flow Volume Basis

This method is typically more difficult than the even-time-interval method described above, because it requires keeping a cumulative running tally of flow volume, which is not normally practical without automated flow monitoring equipment. As with automated composite sampling, flow volume per sample is calculated using the target storm QPF, with consideration for the required composite sample volume and the minimum acceptable number of aliquots, as discussed below (also see ***Section 9*** for guidance on calculating flow volume per sample). Once runoff begins, flow rate is measured periodically (using one of the methods described in ***Section 5***), and sample aliquots are collected each time the pre-determined flow volume per sample has passed the sampling location. Instantaneous and cumulative flow volume can be calculated by inputting the flow data into a portable computer and applying Manning's equation or other appropriate flow equation in the field (see ***Section 5***). Sample aliquots are collected either as manual grabs or by using a peristaltic pump equipped with appropriate tubing and strainer (see ***Section 5***). Each sample aliquot collected is of equal volume (typically 250-1000 mL) and combined into a single composite bottle immediately after collection.

Flow-Proportioning Using Precipitation Measurement

For sites where flow measurement is extremely difficult (such as sites where sheet flow is prevalent) flow-proportional samples may be collected using precipitation measurements

as an analog for runoff flow. The assumption is made that runoff volume is directly proportional to event precipitation. So, instead of calculating flow volume per sample, rainfall depth per sample is determined. A sample aliquot is then collected each time the selected precipitation increment has fallen. Therefore, an on-site rain gauge is required for precipitation measurement (see ***Section 5***). To determine appropriate rainfall amount per sample for a target storm event, simply divide the event QPF by the number of sample aliquots required (the number of sample aliquots required is determined by the total composite volume required and the desired sample aliquot volume, subject to the minimum numbers of sample aliquots per event, as discussed later in this section).

Multi-Bottle Flow-Proportioning

This method of flow-proportional sample collection involves collecting sample aliquots of equal volume at a predetermined time interval throughout the storm event, and recording the flow rate at the time of sample collection. The sample aliquot volume is set in advance, based on the expected duration of the storm and the required composite sample volume, and considering the minimum number of aliquots required (see discussion below). After the storm has ended, a portion of each aliquot is composited to generate a single flow-proportional composite sample. The volume used from each aliquot is directly proportional to the flow rate that was recorded during the aliquot collection. Using this method, the highest flow rate measured during the event is used to determine the scale for the sample volumes added to the composite from each aliquot. For example, for each aliquot, the flow reading taken during sample collection can be divided by the highest flow reading during the event, and that percentage is the percentage of the aliquot that is added to the composite. This method requires more bottles and bottle handling that the other methods described above.

➢ FLOW MONITORING

Flow measurements are necessary to produce flow-weighted composite samples. Flow measurements should be performed utilizing one of the methods discussed in ***Section 5***. If using manual methods, field crews should begin taking flow measurements as soon as possible after stormwater runoff begins (concurrently with sample collection). If automated sampling equipment is utilized, the equipment must be programmed to obtain the desired composite sample volume every time a specified flow volume is recorded, based on the predicted rainfall amount. Methods for programming automatic samplers and flow meters are described in ***Section 9***.

If multiple bottles are used for composite sample collection, or if more flow volume is delivered than expected during a storm event, requiring one or more composite bottle changes per monitoring station, it is necessary to combine the multiple composite bottles to produce a single flow-weighted composite sample. To do this, it is normally necessary to use the collected flow data to determine the amount of sample from each composite

bottle to be used to form the final composite. When using automated equipment, the field crew will typically download data from the flow meter or datalogger, to determine the flow volume represented by each composite bottle. The sample volumes to be used out of each composite bottle can be calculated by the monitoring crew, and the completed calculations faxed or otherwise delivered to the lab. The methods for calculating appropriate sample volumes from each bottle are described below under "Multi-bottle Compositing".

➢ COMPOSITE BOTTLE CHANGING

If an automated monitoring station is used for the collection of composite stormwater samples and a composite bottle change is required, composite bottle changing is conducted using the steps listed below. When conducting monitoring to determine compliance with water quality objectives or to determine receiving water impacts, the more extensive composite-changing protocols presented in ***Appendix F*** should be followed.

1. The automated sampling equipment is placed in pause mode prior to the initiation of a composite bottle change. This action is accomplished in the field or by remote monitoring personnel if the monitoring station is equipped with telemetry.
2. Field personnel should wear clean, powder-free nitrile gloves and practice clean sampling techniques (see above).
3. To change a sample bottle, the end of the pump tubing is removed from the full sample bottle, the full bottle is removed from the sampler and capped with a clean lid, a clean bottle is placed in the sampler, and the tubing end is placed into the clean bottle. Do not allow the exposed tubing end to contact hands or any other surface.
4. After the sample bottle has been changed, the sampler is closed and the sampler keypad is used to place the sampler in sampling mode. The field supervisor or remote operation personnel are notified as soon as the bottle change is complete.
5. The sampling team fills out the appropriate information on the label of the collected composite sample bottle(s).
6. The collected composite bottle(s) are surrounded with ice, and secured inside the vehicle for transport.
7. Verify that the automatic sampler has been placed in sampling mode, if sampling is to continue. Visually inspect the components for possible damage or clogging, to be sure the system will be ready to continue sampling, or is ready to sample the next storm.

➢ SAMPLE REPRESENTATIVENESS EVALUATION

Immediately following sample collection, composite sample representativeness must be evaluated to determine whether samples meet the project minimum acceptable storm capture parameters (number of aliquots and percent storm capture). Samples not meeting these criteria are generally not analyzed. However, the Caltrans Project Coordinator should be consulted to make the decision whether or not to analyze the samples.

Percent storm capture is the percentage of the total event flow that passes the sampling station during which sample collection occurred (i.e., the portion of the runoff represented by the composite sample). This is calculated simply by dividing the flow volume that passed the sampling station during sample collection by the total flow that passed the sampling station during the entire monitoring event.

The minimum acceptable number of sample aliquots and minimum acceptable storm percent capture depend on the total event precipitation, as shown in Table 10-1. The specified minimum number of sample aliquots is intended to ensure adequate representativeness of the composite sample throughout the monitoring event. Higher numbers of sample aliquots are desirable whenever possible, subject to the practical limitations of sample collection.

Table 10-1. Monitoring Event Representativeness Requirements

Total Event Precipitation	*Minimum Acceptable Number of Aliquots*	*Percent Capture Requirement*
0-0.25”	6	85
0.25-0.5”	8	80
0.5-1”	10	80
>1”	12	75

➢ MULTI-BOTTLE COMPOSITING AND COMPOSITE SAMPLE SPLITTING

Procedures for combining multiple composite samples to produce a single sample, and the procedures for splitting samples into multiple sample bottles are described below.

Multi-bottle Compositing

When multiple composite sample bottles are filled at a single site during a single storm monitoring event, the sample bottles are typically composited together to produce a single composite sample representing the entire monitoring event.

In order to combine multiple sample bottles to generate a single representative composite sample, the following two items must be determined: 1) the percent of the sampling event flow represented by each individual sample bottle, and 2) which of the sample bottle(s), if

any, will limit the compositing of samples. Because individual sample bottles will likely contain different volumes, one bottle will likely dictate the total available sample volume. Individual sample bottles may contain different sample volumes for several reasons. For example, the number of aliquots may differ in each bottle if runoff ceased before triggering all programmed sample aliquots. Composite bottle volumes may also differ slightly from unequal aliquot volumes, sometimes caused by pump tubing blockages or wear.

Each individual composite sample corresponds to the volume of stormwater runoff that passed the sampling point during the collection of that composite sample. Composite samples are mixed in relative proportion, according to the percentage of total volume that passed the sampling point during the storm event. Therefore, to properly combine multiple composite samples, the following must be known:

- Individual volumes in each sample bottle
- Total runoff flow volume that passed during the collection of each individual sample bottle, and the total runoff volume for the monitoring event

Multiple composite samples should be combined using the following formulas:

$V_n/V_t = P_n$, and

$S_t * P_n = S_n$

Where;

V_n = the volume of flow that passed during the collection of bottle n
V_t = the total volume of flow that passed during the sample collection event
P_n = the percent of the total sampled flow represented by bottle n
S_t = the total volume of sample collected in all bottles combined
S_n = the volume of sample contributed from bottle n toward the combined composite sample

The following is an example of how multiple composite samples are combined:

Bottle #1 = 8 L of sample 10,000 CF passed during the collection of bottle #1 (V_1)

Bottle #2 = 10 L of sample 15,000 CF passed during the collection of bottle #2 (V_2)

Total volume passed during sample collection = 25,000 CF (V_t)

Total composite sample collected = 18 liters (S_t)

Bottle #1, % of total flow = % of composite = 10,000/25,000 = 40% (P_1)

Bottle #2, % of total flow = % of composite = 15,000/25,000 = 60% (P_2)

Therefore, the single composite is made up of 40% from bottle #1 and 60% from bottle #2. Since 40% of the total sample volume collected (18 liters) equals 7.2 (S_1) liters and 60% equals 10.8 liters (S_2), it is apparent that bottle #2 has limited sample volume for compositing. Therefore, the entire 10 liters of sample from bottle #2 is mixed with the following volume (X) from bottle #1.

10 liters/60% = X liters/40%

X (the volume required from bottle #1) = 6.7 liters

The two composite samples are combined by adding 6.7 liters from sample bottle #1 to 10 liters from sample bottle #2.

Each sample bottle must be well-mixed prior to pouring off into another composite bottle. The sample is mixed thoroughly by shaking or otherwise agitating the composite bottle to prevent sediment from remaining on the bottom of the bottle. Throughout the sample compositing procedures, clean, powder-free nitrile gloves are used for bottle and lid handling. This process can be done by analytical laboratory personnel, or by field sampling personnel in a clean, dry setting.

Composite Sample Splitting

Composite samples collected in a single composite sample bottle are poured, by the analytical laboratory or the sampling team, into individual sample bottles for analysis (to limit contamination it is recommended that splitting be conducted by the laboratory). When a composite sample duplicate is required, the sampling team will be required to split the composite sample into two composite bottles to generate a subsampling duplicate. As with field duplicate samples (replicate samples collected simultaneously in the field), subsampling duplicates (replicate samples generated from a single composite sample bottle) should be submitted to the analytical laboratory "blind" (labeled using a pseudonym site name). Below are three examples of composite sample splitting procedures:

<u>Sample Splitting Example #1</u>

1. Sample storage bottles are labeled for specific analyses.
2. Clean powder-free nitrile gloves are worn for handling of bottles and lids.
3. Any item that will contact the sample is cleaned using protocols presented in ***Appendix E***.
4. Clean, specially blown borosilicate glass vessels are used to composite and mix samples (vessels have glass spigots with Teflon stopcocks).

5. Clean, Teflon coated magnetic mixing bars are used to stir the sample continuously before and during sample pour-off into individual sample containers (check with analytical laboratories for recommended sample volumes for individual constituents).

Sample Splitting Example #2

1. Sample storage bottles are labeled for specific analyses.
2. Clean powder-free nitrile gloves are worn for handling of bottles and lids.
3. Any item that will contact the sample is cleaned using protocols presented in ***Appendix E***.
4. During continuous manual composite sample agitation, sample is drawn from the bottle into individual sample containers using a portable peristaltic pump and clean tubing (check with analytical laboratories for recommended sample volumes for individual constituents).

Sample Splitting Example #3 (USGS method)

1. Sample storage bottles are labeled for specific analyses.
2. Clean powder-free nitrile gloves are worn for handling of bottles and lids.
3. The composite sample is mixed thoroughly by carefully shaking composite bottle, with lid in place, until the sample is well mixed.
4. Immediately after mixing, the composite sample is poured into a clean Teflon funnel/splitter with clean tubes leading to individual sample containers (check with analytical laboratories for recommended sample volumes for individual constituents).

Sample Splitting Example #4

1. Sample storage bottles are labeled for specific analyses.
2. Clean powder-free nitrile gloves are worn for handling of bottles and lids.
3. The composite sample is mixed thoroughly by carefully shaking composite bottle, with lid in place, until the sample is well mixed. For large composite bottles, the use of a swiveling mechanical bottle holding/mixing/pouring device is recommended.
4. Immediately after mixing, the composite sample is poured off into individual sample storage bottles and the bottles are capped (check with analytical laboratories for recommended sample volumes for individual constituents). Step 3 is repeated immediately prior to filling each sample storage bottle.

➢ SAMPLE PRESERVATION

All samples are kept on ice or refrigerated to 4° Celsius from the time of sample collection until delivery to the analytical laboratory. Refrigerated automatic samplers are ideal for keeping composite samples cool during sample collection. Where refrigerated automatic samplers are not used, composite samples are kept on ice from the time sampling is initiated. Ice is checked regularly to insure that the sample is kept cool. Grab samples are placed in an ice chest with ice immediately following collection.

In addition to keeping stormwater samples cool it is also important to minimize the exposure of the samples to direct sunlight, as sunlight may cause biochemical transformation of the sample, resulting in unreliable analytical results. Therefore, all samples are covered or placed in an ice chest with a closed lid immediately following collection or removal from the automatic sampler enclosure.

Samples to be analyzed for certain constituents (depending on analytical laboratory method) require that special chemical preservatives be added to the sample, either in the bottle prior to collection, or after collection, at the analytical laboratory. The later is recommended, as this may reduce logistical problems in the field (e.g., loss of preservative during sample collection). ***Section 12*** discusses appropriate sample preservation in more detail.

➢ SAMPLE FILTRATION

Sample filtration is required when collecting samples for dissolved metals determinations. Because of the added possibilities for field contamination during stormwater sampling, it is recommended that filtration for dissolved metals be performed in the laboratory. The laboratory provides a controlled environment for sample filtration. However, it is important that the samples be transported promptly to the laboratory, and filtered immediately upon receipt. The laboratory must be notified in advance that samples will be delivered and that immediate filtration for dissolved metals analysis will be required.

If filtration can be done in the field in such a way as to minimize the possibility of contamination, and if the analytical laboratory is a substantial distance from the monitoring location, field filtration may be preferable because filtration could be more immediate. Filtration should be performed using methods and filtration apparatus specified in EPA Method 1669 (USEPA, 1996). Field filtration is a viable alternative particularly when a mobile laboratory or a walk-in shelter is available for the filtering activity.

➢ SAMPLE DELIVERY/CHAIN OF CUSTODY

All samples must be kept on ice, or refrigerated, from the time of onset of sample collection to the time of receipt by laboratory personnel. If samples are being shipped to the laboratory, place sample bottles inside coolers with ice, ensure that the sample bottles are well packaged (i.e., with bubble wrap, foam, etc.), and secure cooler lids with packaging tape.

It is imperative that all samples be delivered to the analytical laboratory and analysis begun within the maximum holding times specified by laboratory analytical methods (see ***Section 12***). For example, if the fecal coliform test is required, analysis must be started within 8 hours of sample collection (the analytical method allows 6 hours for transportation to the laboratory and 2 hours to begin analysis). Similarly, soluble reactive phosphorus or nitrite analyses must be performed within 48 hours after sample collection. To minimize the risk of exceeding the holding times, samples must be transferred to the analytical laboratory as soon as possible after sampling. The field crew must in such cases coordinate activities with the analytical laboratory to ensure that holding times can be met.

Chain-of-custody (COC) forms must be filled out by the sampling team for all samples submitted to the analytical laboratory. The purpose of COC forms is to keep a record of the transfer of sample custody, and requested analyses. Sample date, sample location, and analysis requested are noted on each COC, including specification of lab quality control requirements (e.g., laboratory duplicate samples and matrix spike/matrix spike duplicate (MS/MSD) samples; see ***Section 11***). Any special instructions for the laboratory should also be noted, for example, requesting that filtration for dissolved metals be conducted immediately. Customized project specific COCs, that include standard information (e.g. contact information, constituents and methods, and special notes) are recommended. Copies of COC forms are kept with field notes in a field log book. COC forms should be checked to be sure all analyses specified by the sampling plan are included. Review of the COC forms immediately following a storm event gives the data reviewer a chance to review the field crews' requests and then to notify the laboratory of additional analyses or necessary clarification. An example of a customized COC form is presented as Figure 10-1.

CHAIN OF CUSTODY RECORD

COC No. _____

Company Submitting Samples		Project Name:	LABORATORY	
Street	Attn:		Street	Contact:
City, State Zip code			City, State Zip code	
Phone number	Fax:	Project No:	Phone number	Fax:

Year: *Event:* *Sampled By:* _____

	SAMPLE IDENTIFICATION	Date	Time	# of Containers	Container Type	Matrix: Composite Water	Matrix: Water (Grab)	Matrix: Other	pH (EPA 150.1)	Specific Conductance (EPA 120.1)	Hardness (EPA 130.2)	TSS (EPA 160.2)	Nitrate-N (EPA 300)	TKN (EPA 351.3)	Total Phosphorous (EPA 365.3)	Total Metals (Cu/Pb/Zn EPA 200.8)	Diss. Metals (Cu/Pb/Zn EPA 200.8)	TPH-Gasoline (EPA 8015M)	Fecal Coliform			SPECIAL INSTRUCTIONS/ COMMENTS
									7	7	2	7	7	3	3	2	6	7	7			< Preservative Type
1.																						1) Measure pH and specific conductance upon receipt
2.																						2) Filter and acidify dissolved metals upon receipt
3.																						3) Perform MS/MSD on designated sample for all
4.																						analyses except for conventionals and bacteria
5.																						
6.																						**Composite Splitting** **Bottles**
7.																						pH/Spec. Cond. 1 L Plastic
8.																						TSS 1 L Plastic
9.																						Hardness 200 mL Plastic
10.																						TKN/Phosp. 1L Plastic
11.																						Nitrate-N 500mL Plastic
12.																						Total Cu, Pb, Zn 500mL Plastic
13.																						Dissolved Cu, Pb, Zn 500mL Plastic
14																						

Relinquished By (sign/print)	Company	Date	Time	Received By (sign/print)	Company
/				/	
/				/	
/				/	

Preservative Type: 1. HCL 2. HNO3 3. H2SO4 4. NaHSO4 5. Other 6. Filter & acidify 7. Ice **Container Type:** VOA Vials: VO Plastic: PL Glass: GL	**Turnaround Time:** 10/30 days (fax/final) **Reporting Level:** QC Sum + EDD	Remarks (by laboratory):

Figure 10-1. Example Chain-of-Custody Form

SECTION 11
QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

The quality of analytical data is dependent on the ways in which samples are collected, handled and analyzed. To ensure that data meet project data quality acceptability limits or objectives (DQOs,) a Data Quality Evaluation Plan (DQEP), which includes QA/QC review procedures for both field and laboratory measures, should be included in the sampling and analysis plan (SAP) prior to implementing the stormwater monitoring program (see ***Sections 6*** and ***13***).

The three major categories of QA/QC checks are accuracy, precision, and contamination. Accuracy is assessed by measuring percent recovery of a known quantity of analyte (e.g. via a matrix spike or laboratory control spike) and comparing it against prescribed acceptability limits. Precision is assessed by calculating the relative difference between analytical results for duplicate samples and comparing the relative percent difference (RPD) against prescribed acceptability limits. Contamination is assessed using blank samples to identify sources of contamination.

Improved control of data quality is achieved by incorporating the following elements of a typical stormwater monitoring QA/QC program into the sample collection effort:

KEY TOPICS

- **Duplicate Samples**
- **Blank Samples**
- **Matrix Spikes/Matrix Spike Duplicate Samples**
- **QC Sample Schedule**

Each of these types of samples and the relevant responsibilities of monitoring field personnel are described below, followed by a discussion of recommended minimum frequencies for the various types of QC samples.

The results of the field QC samples are then used to evaluate the quality of the reported data (data evaluation is discussed in ***Section 13***).

➢ DUPLICATE SAMPLES

Analytical precision is a measure of the reproducibility of data and is assessed by analyzing two samples that are intended to be identical. Any significant differences between the samples indicate an unaccounted-for factor or a source of bias. There are typically two types of duplicate samples that require special sampling considerations: field duplicates and laboratory duplicates.

Once duplicate samples have been analyzed by the laboratory, the results are evaluated by calculating the RPD between the two sets of results for each constituent. This serves as a measure of the reproducibility, or "precision" of the sample collection and analysis. Calculation of RPD is discussed further in the QA/QC data evaluation section of this document (***Section 13***).

Field Duplicates

Field duplicates are used to assess variability attributable to collection, handling, shipment, storage and/or laboratory handling and analysis. The procedures for collecting field duplicate samples will depend upon the sampling method being used, and should simulate the actual sampling protocols. For example, if collecting grab samples, duplicate samples may be collected by filling two grab sample bottles at the same location either by holding both bottles in the middle of the water flow to be sampled. If bailers or other intermediate devices are used in grab sampling, all field protocols should be exactly duplicated with duplicate sets of equipment, to collect the duplicate sample simultaneously with or immediately following collection of the environmental sample. When collecting duplicate composite samples, the following procedures should be used:

- Collect enough sample for both environmental sample analysis and field duplicate analysis (amount will be specified by the analytical laboratory; see ***Section 12***) in one or more composite bottles.
- Splitting the composite samples is discussed in detail in ***Section 10***. Field duplicate samples should be split in the same manner as the environmental samples, and are taken in random order along with the environmental samples to assess the variability introduced during splitting and laboratory analysis.

Field duplicate samples should be submitted to the laboratory "blind" (i.e. not identified as a QC sample, but labeled with a different site identification than the regular sample).

Laboratory Duplicates

Laboratory duplicates (also called laboratory splits) are used to assess the precision of the analytical method and laboratory handling. For the laboratory duplicate analysis one sample will be split by the analytical laboratory into two portions and each analyzed.

When collecting samples to be analyzed for laboratory duplicates, typically double the normal sample volume is required. This requires filling a larger size sample bottle, or filling two normal size sample bottles, labeling one with the site name and the second with the site name plus "laboratory duplicate". Laboratory duplicate samples are collected, handled, and delivered to the analytical laboratory in the same manner as environmental samples.

➢ BLANK SAMPLES

Blanks are prepared to identify potential sample contamination occurring during field collection, handling, shipment, storage, and laboratory handling and analysis. Blanks are evaluated during various stages of the sampling and analytical process to determine the level of contamination, if any, introduced at each step. The collection and uses of the types of blank samples associated with typical stormwater monitoring field procedures are described below. "Blank water" refers to contaminant-free water provided by the laboratory performing the environmental and blank analyses. Typically, this water is the laboratory's reagent water that is used in the analytical or cleaning processes, as well as for their method blanks. The analytical laboratory should be consulted when selecting the source of the blank water.

Method Blanks

For each batch of samples, method blanks (also called control blanks) should be run by the laboratory to determine the level of contamination associated with laboratory reagents and glassware. Method blanks are prepared by the laboratory by analysis of laboratory reagent or blank water. Results of the method blank analysis should be reported with the sample results. At a minimum, the laboratory should report method blanks at a frequency of 5% (one method blank with each batch of up to 20 samples).

Trip Blanks

Trip blanks are used to determine whether sample contamination is introduced during sample transportation and delivery. Trip blanks are prepared at the analytical laboratory, by filling the sample bottle with deionized water and securing the bottle lid. Trip blanks are transported to and from the sampling site with normal sample bottles. Trip blanks are analyzed like normal samples.

Equipment Blanks

Before using sampling equipment for sample collection activities, blanks should be collected to verify that the equipment is not a source of sample contamination. Stormwater monitoring programs normally include equipment blanks to check sample tubing and strainers, and sample bottles, especially composite bottles. Equipment blanks are usually prepared at the beginning of the monitoring season, and are collected by passing blank water through clean equipment. Equipment blanks are collected using clean techniques, prior to on-site sample collection, before the equipment has been contaminated by environmental sample water or other sources. Equipment blank collection normally requires a two-person field crew. After collection, equipment blanks are capped, placed in an ice chest with fresh ice or frozen refreezable ice packets, and delivered to the analytical laboratory in the same manner as environmental samples.

If using manual collection methods (i.e. bailers), fill the bailer or other collection device with blank water in the field and pour the water into clean sample bottle(s). If an automatic sampler is being used, place the cleaned strainer on the end of the clean tubing, and install the tubing through the sampler. Do not install the tubing and strainer into the pipe or channel, but leave the tubing coiled up beside the sampler. Prevent the strainer or exposed tubing end from contacting anything other than the inside of a new plastic bag during this process. Then insert the strainer into the bottle containing the blank water and pump forward through the clean suction tubing, into clean composite bottle(s) and/or grab sample containers.

Equipment blanks are analyzed using the same methods as those used for normal sample analysis and submitted to the analytical laboratory "blind" (disguised as a regular environmental sample by labeling with a pseudonym).

To account for any contamination introduced by sampling containers, blanks must be collected for composite bottles and laboratory bottles used for sample storage for metals analysis. A sampling container blank is prepared by filling a clean container with blank water and measuring the concentrations of selected constituents (typically metals and trace organics for composite bottles; metals analysis only for metals storage bottles). These blanks may be submitted “blind” to the laboratory by field personnel or prepared internally by the laboratory. Collection of sample container blanks may not be required if certified pre-cleaned bottles are used. The manufacturer can provide certification forms that document the concentration to which the bottles are “contaminant-free”; these concentrations should be equivalent to or less than the program reporting limits. If the certification level is above the program reporting limits, 2% of the bottles in a “lot” or “batch” should be blanked at the program detection limits with a minimum frequency of one bottle per batch. A batch is a group of samples that are cleaned at the same time and in the same manner; or, if decontaminated bottles are sent directly from the manufacturer, the batch would be the lot designated by the manufacturer in their testing of the bottles.

Field Blanks

Field blanks are necessary to evaluate whether contamination is introduced during field sampling activities. Field blanks are prepared by the field crew, under normal sample collection conditions, at some time during the collection of normal stormwater samples. Field blanks are prepared by filling a large carboy or other appropriate container with blank water, transporting the container to the field and processing the water through the same sampling procedures to be used for sample collection. If grab sample collection is required, grab sample field blanks should be prepared by pouring a sample directly from the bottle of blank water, into the grab sample containers. Grab sample blanking should imitate environmental sampling as closely as possible by using grab poles, clean intermediate containers, and other clean equipment in the same manner. For composite field blanks, pour the blank water directly into clean composite bottles at the sampling site, label as an environmental sample, and submit “blind” to the laboratory. The filled blank sample bottles should be sealed and sent to the laboratory to be analyzed for the required constituents.

In addition to the minimum field blank collection requirements indicated in Table 11-1, it is important that field blanks are collected at a frequency no less than once per field sampling team per sampling season. Additional blanks should be collected when there is a change in sampling personnel, equipment, or procedures. It may also be desirable to prepare field blanks prior to any actual sampling events as an advance check of the overall sampling procedures.

In addition, if any filtration of samples is performed in the field, some field blanks should be filtered before being transported back to the laboratory. Filtered blanks help to ensure that contamination is not attributable to filtration equipment, such as hoses, housing, filters, and technique, whereas unfiltered blanks check for contamination from containers and preservatives.

➢ MATRIX SPIKES/MATRIX SPIKE DUPLICATE SAMPLES

Matrix spike (MS) and matrix spike duplicate (MSD) analyses are used to assess the accuracy (MS) and precision (MSD) of the analytical methods in the sample matrix. The analytical laboratory prepares matrix spike samples by splitting off three aliquots of the environmental sample and adding known amounts of target analytes to two of the three environmental sample aliquots. The results of the analysis of the unspiked environmental sample are compared to the MS analysis results, and "percent recovery" of each spike is calculated to determine the accuracy of the analysis. The results of the MS analyses are compared to calculate RPD as an additional measure of analytical precision.

When collecting samples to be specified for MS/MSD analysis, typically triple the normal sample volume is required. This will require filling a larger size sample bottle, or filling three normal size sample bottles, labeling one with the site name and the other two with the site name plus "MS/MSD". MS/MSD samples are collected, handled, and delivered to the analytical laboratory in the same manner as environmental samples. Analytical laboratories often will perform MS/MSD analyses at no charge on a specified sample when a certain minimum number of samples are submitted for analysis.

➢ QC SAMPLE SCHEDULE

Table 11-1 summarizes the minimum frequencies of QC sample collection/preparation for Caltrans stormwater monitoring programs based on EPA Guidance (EPA, 1995). These frequencies are minima and may be increased depending on the nature and objectives of the study being undertaken or if QA/QC problems (e.g. contamination) are discovered. An adequate QC sample schedule should be included in the analytical budget for the monitoring program.

Table 11-1. Recommended QC Sample Frequency

QA/QC Sample Type	*Minimum Sampling Frequency*	*Constituent Class*
Field Duplicate	Once every ten samples collected at a given site or once per sampling station per project, whichever is more frequent.	All
Lab Duplicate	Once every ten samples collected at a given site or once per sampling station per project, whichever is more frequent.	All
Equipment Blank	Equipment blanks should be collected prior to each sampling season for each piece of equipment to be used for sample collection (bailers, pumps, and carboys).	Metals and other common contaminants. [1]
Bottle Blanks	Composite and sample bottles should be blanked every batch [2]; or manufacturer or laboratory-certified to concentrations below the reporting limits used for the sampling program.	Metals and other common contaminants. [1]
Field Blank	Once every ten samples collected at a given site or once per sampling station per project, whichever is more frequent.	Metals and other common contaminants. [1]
Matrix Spike/Matrix Spike Duplicate	Once every ten samples collected at a given site or once per sampling station per project, whichever is more frequent.	Metals and other common contaminants. [1]

Notes:

[1] Other common contaminants include phthalate compounds, pesticides, organic carbon (TOC and DOC), nitrate as N, and PAHs. Analyze blanks for these constituents as appropriate for constituents monitored in specific projects.

[2] A batch is defined as the group of bottles that have been cleaned at the same time, in the same manner; or, if decontaminated bottles are sent directly from the manufacturer, the batch would be the lot designated by the manufacturer in their testing of the bottles.

A QC sample schedule should be developed, included in the SAP, and followed closely by field personnel. The project QC sample schedule should meet the minimum QC sample frequency criteria over the term of the project. In some cases, QC samples at one site may be applied to an analogous situation at another site. For example, if the same equipment and protocols are used at Site A and Site B, contamination checks at one site can be applied at both sites; if the matrices at Site Y and Site Z are the same (i.e., both urban runoff from similar types of watersheds), then the MS/MSD results at one site can be applied at both sites. The minimum frequency criteria must still be met; however, the QC sample schedule should consider the location of each QC sample to maximize coverage at all project sites. A QC sample schedule should, at a minimum, indicate the types and frequency of QC sample collection, site of QC sample collection, and QC sample pseudonyms for samples that will be submitted "blind" to the laboratory. An example of a QC sample schedule is shown in Table 11-2 below. This example schedule demonstrates the distribution of QC samples over one year of monitoring and assumes a

total of ten events over a two-year period. The example QC sample frequency exceeds the minimum frequency criteria for MS/MSD and field blank samples because the variability noted in sample matrices and the consistent contamination problems previously noted for this example project. QC sample scheduling should consider project-specific issues such as this.

Table 11-2. Example QC Sample Schedule

Site	***Pre-Season***	***Event #1***	***Event #2***	***Event #3***	***Event #4***
Site 1		MS/MSD		Field Duplicate (Site C)	Field Blank (Site B)
Site 2	Equipment Blank (Site A1)	Field Blank (Site B)	MS/MSD		Lab Duplicate
Site 3		Field Duplicate (Site C)	Field Blank (Site B)	MS/MSD	
Site 4	Equipment Blank (Site A2)		Lab Duplicate	Field Blank (Site B)	MS/MSD
Laboratory	Composite bottle blank; sample bottle blanks				

Notes:
- Equipment blanks, field blanks and field duplicates are sent to the laboratory "blind", labeled as Site A, Site B, and Site C respectively.
- This is a schedule assumes ten total events over a two-year period.

Because of unforeseen storm characteristics or equipment malfunctions, adequate volume to perform all QC sample analyses may not be available for each monitoring event. In this case MS/MSD analysis should be prioritized ahead of all other QC samples requiring environmental sample volume. If there is inadequate volume to do a complete MS/MSD analysis, duplicate analysis should be performed first. Any variations from the sampling plan should be documented and the monitoring program schedule should then be adjusted to ensure that the minimum number of QC samples are performed during the project.

SECTION 12

LABORATORY SAMPLE PREPARATION AND ANALYTICAL METHODS

This section describes the steps to be taken by analytical laboratories to prepare for monitoring events, and the procedures laboratories will use for stormwater sample analyses. The following topics are discussed:

KEY TOPICS

- **Laboratory Selection and Contracting**
- **Pre-Sampling Preparations**
- **Sample Storage and Handling Prior to Analysis**
- **Reporting Limit Requirements**
- **Analytical Methods**
- **Laboratory Data Package Deliverables**

➢ LABORATORY SELECTION AND CONTRACTING

Important considerations in selecting an analytical laboratory include location, performance, ability to meet analytical reporting limits (RLs), and experience with the type of samples that will be generated by the monitoring program. The various analytical needs of the monitoring program may warrant the selection of multiple laboratories.

Selecting a laboratory in close proximity to the study area is important for convenience, logistical support, and analysis of constituents with very short holding times (such as coliform bacteria). A local laboratory can provide sample bottles, supplies, and equipment on short notice, and can quickly make arrangements for sample preservation and analysis that may need to be performed within a short holding time, at night or on weekends. If the latter is anticipated, the laboratory contract should provide for off-hours sample handling and analysis by the laboratory.

The laboratory should have a proven record of performance with the particular types of analysis to be conducted for the project. Ideally, the laboratory will have demonstrated experience conducting the analysis in a comparable sample matrix.

Department of Health Services (DHS) certification is required for Caltrans analytical work. However, in certain cases it may be difficult to contract for all required analyses with DHS-certified laboratories. In such cases, alternative arrangements may be made provided that the exception is documented and approved by the Caltrans task order manager. For example, if constituent reporting limits cannot be adequately achieved by certified laboratories, a research level laboratory with a proven ability to perform the needed analysis can be used with approval from the Caltrans task order manager. Such laboratories may include out-of-state commercial laboratories or university/research

laboratories with demonstrated expertise in EPA-sponsored research or method development programs.

It is important to ensure that the selected laboratory is able to meet the RLs derived for the project (Table 12-1), or alternatively, that the lab is able to reliably report constituent concentrations above their RL based on site-specific historical data. It is often necessary to utilize more than one analytical laboratory to meet the prescribed RLs. If one laboratory is unable to meet the project RLs for certain constituents, it may be necessary to ship those samples to other laboratories that can meet the project RLs. If multiple laboratories are selected, it is suggested that the monitoring program manager contract directly with all labs to allow for increased quality control and better response. This will require the monitoring program manager to package and ship samples to the appropriate laboratories. If multi-bottle sample compositing (i.e., combining multiple composite samples to create one representative sample) is necessary, the monitoring program manager should coordinate with the local laboratory to composite samples prior to shipping when possible. See ***Section 10*** for multi-bottle compositing and sample delivery information.

Finally, it is necessary that laboratories be made contractually accountable to meet all Caltrans' data quality acceptability limits or objectives (DQOs) and project specifications. This is discussed in more detail later in this section.

➢ PRE-SAMPLING PREPARATIONS

The analytical laboratory will be involved in a number of activities prior to the actual analysis of stormwater samples, including:

- Determination of key laboratory performance requirements (e.g., maximum reporting limits, turnaround times, report formats) for analytical services contract.
- Review and comment on the data quality evaluation plan (DQEP), QC sample schedule, and QC sample volumes. This overall package is sometimes referred to as the QA/QC plan.
- Providing sampling team with clean sample containers and blank water.
- Coordination with sampling team prior to each anticipated storm sampling event.

Determination of Laboratory Performance Criteria

The analytical laboratory must analyze the stormwater samples using methods that will achieve Caltrans' DQOs for the project (see ***Section 2***). The contract for analytical services should specify laboratory performance criteria designed to ensure that the project DQOs will be met. The contract should specify the following:

- Analytical reporting limits
- Holding times
- Types and frequency of QA/QC analyses
- Quality control performance limits
- Sample turnaround times
- Electronic and hard copy report formats
- Corrective action procedures

In addition, the contract with the laboratory should specify that at least 90% of the sample results must meet the QA/QC criteria and be deemed usable for the project.

Laboratory Input to Project QA/QC Plan

The contract laboratory should review and provide input to the QA/QC plan for each Caltrans stormwater monitoring project. This input will help ensure that the QA/QC plan specifies the correct sample containers, sample volumes, holding times, analytical methods, reporting limits, and the correct points of contact for communications between field and laboratory personnel. In addition, the laboratory should be involved early in the process so they can provide feedback on methods and performance standards during the planning phase.

Sample Containers, Blank Water

Each analytical method has specific requirements with regard to the type of sample container (e.g., plastic, glass, Teflon, amber glass), the size of the container, and the number of containers. Table 12-1 shows the appropriate sample containers for the analytical methods recommended for the Caltrans stormwater monitoring program. As noted above, the analytical laboratory should review the QA/QC plan for each Caltrans stormwater monitoring project to ensure that the plan specifies the appropriate sample containers, volumes, and preservatives. As discussed in ***Section 10***, sampling personnel will need to request the appropriate containers from the laboratory prior to each sampling event. The containers needed for a given project will vary depending on the constituents to be analyzed, the sample collection procedure, and the DQOs. For example, stormwater monitoring programs often include composite samples, wherein subsamples collected during a storm event may be combined in one or more large containers. After the composite sample has been delivered to the laboratory, water is transferred from the

composite sample containers into the individual containers required for each analysis, and the individual samples are then filtered and/or preserved as required.

If a given project calls for collection of composite samples, the field personnel must obtain the appropriate composite sample containers from the laboratory; however, the field personnel do not need the individual containers required for each analysis. The composite sample bottle container must be large enough to provide sufficient volume of sample for all of the individual constituents to be analyzed. The container type should be compatible with all of the constituents to be analyzed. Although plastic and Teflon are the preferred container materials for metals, borosilicate glass is the most common material for composite sample containers because it is also compatible with organic constituents and is more cost effective than Teflon. However, bottle contamination issues should always be assessed with blank samples, regardless of the bottle material (see ***Section 11***).

For stormwater projects that specify collection of grab samples, field personnel must obtain the appropriate pre-cleaned bottles from the laboratory prior to the sampling event.

Some projects may require use of "ultra-clean" techniques (USEPA, 1996) in order to meet the project DQOs. Such techniques may entail use of special cleaning procedures for the sample containers, which should be specified in the contract for analytical services and the QA/QC plan for the project, to ensure that the containers obtained from the laboratory have been cleaned in accordance with the EPA guidance. ***Appendix E*** describes these cleaning procedures in detail.

Sample volumes necessary for the requested analyses should be confirmed with the laboratory prior to sample collection, including sufficient sample volumes for the required laboratory QA/QC analysis. As discussed in ***Section 11***, laboratory QC samples that make use of sample water provided by the field crew include splits (laboratory duplicates), matrix spikes, and matrix spike duplicates. Additional sample water will also be required for field duplicate QC samples, as discussed in ***Section 11***.

If field blanks are to be collected, the laboratory also will need to provide sufficient quantities of blank water and appropriate containers (see ***Section 11***). The blank water supplied by the laboratory should be the same as the water used for equipment cleaning.

Laboratory Coordination Prior to a Sampling Event

It is important for the task manager to notify the laboratory of an anticipated storm sampling event so that the laboratory can prepare for possible off-hour sample delivery, and to set up for any analyses with short holding times. The laboratory contact should be notified regarding the number of samples anticipated, approximate date and time of sampling (if known), and when sample containers, blank water or ice chests will be required.

In addition, the laboratory should be made aware of specific project requirements such as required laboratory performance objectives, required QC samples, and reporting requirements.

➢ SAMPLE STORAGE AND HANDLING PRIOR TO ANALYSIS

To minimize the chance of sample contamination and unreliable analytical results, special measures must be taken during the storage and handling of samples prior to analysis. For example, samples must be collected and stored in the appropriate containers and preserved. If composite samples are collected, sample splitting must be conducted to properly store and preserve the samples. In addition, some analytical methods require filtration of the sample prior to analysis. Finally, samples must be analyzed within established holding times to ensure reliability of the results. Each of these measures is discussed in more detail below.

Composite Splitting

As mentioned above, if composite sampling procedures are used, the samples must be split prior to analysis. It is recommended that composite sample splitting be conducted by the analytical laboratory or in another similarly controlled environment to minimize the chance of contamination. Clean techniques should be used when handling and splitting the composite sample. ***Section 10*** explains the sample splitting procedures in detail.

Sample Filtration

Sample filtration is required when collecting samples for dissolved metals determinations. It is recommended that filtration for metals be conducted by the analytical laboratory to reduce the potential for contamination in the field, especially during storm conditions. USEPA specifies the use of a 0.45 µm, 15 mm diameter or larger, tortuous-path capsule filter or equivalent (USEPA, 1996). To minimize dissolved/suspended phase partitioning of metals from the time of sample collection to the time of analysis, it is essential that the laboratory perform the sample filtration promptly. The field crew should therefore specify "filter for dissolved metals immediately upon receipt" on the sample chain-of-custody form, and coordinate this activity with the laboratory in advance.

Sample Preservation

Chemical preservatives are added to the samples for certain analyses to prolong the stability of the constituents during storage. Table 12-1 lists the required sample preservatives for various types of analytical constituents. If composite sampling procedures are used, no preservatives are added to the composite container, because no single chemical preservative is suitable for all of the constituents to be analyzed. The laboratory must first divide the composite sample into the appropriate bottle for each analysis, and then add chemical preservatives as appropriate for each analysis. If grab

sampling procedures are used (i.e., field personnel directly fill the containers required for each analysis), the laboratory should add the appropriate preservative to each sample container immediately upon receipt at the laboratory. Use of bottles pre-filled with preservative is not recommended, as this may increase logistical problems (e.g., field crews have to avoid loss of preservative when collecting samples).

Holding Times

Maximum acceptable holding times are method-specified for various analytical methods and analytes (see Table 12-1). The holding time starts when sample collection is complete and is counted until extraction/preparation or analysis of the sample. The time of collection of the final sample aliquot is considered the "sample collection time" for determining sample holding time for composite samples that represent less than 24 hours of flow (APHA, *et al.,* 1998). If the composite sample collection period exceeds 24-hours, the composite sample bottle(s) should be replaced at or prior to the end of each 24-hour period. For constituents with short holding times, such as 48-hours or less, composite sample volume should be removed from each 24-hour composite for analysis as necessary to comply with holding time requirements. If a sample is not analyzed within the designated holding times, the analytical results may be suspect (see ***Section 13***). Thus, it is important that the laboratories meet all specified holding times and make every effort to prepare and analyze the samples as soon as possible after they are received. Prompt analysis also allows the laboratory time to review the data and, if analytical problems are found, re-analyze the affected samples.

Table 12-1 lists the maximum acceptable analytical holding times for a comprehensive list of constituents potentially monitored in Caltrans projects. Some of these holding times are short and will require the laboratory to immediately handle the sample once received. For example, the fecal coliform test must be started within 8 hours of sample collection. Similarly, BOD_5 or nitrite analyses must be performed within 24 and 48 hours, respectively, after sample collection. Holding times may be a factor affecting allowable sampling times if the laboratory has not agreed to work evenings or weekends.

To minimize the risk of exceeding the holding times, stormwater samples must be transferred to the analytical laboratory as soon as possible after sampling is complete. Moreover, the laboratory should be notified before the sampling begins so that it can prepare to analyze the samples immediately upon receipt.

➢ REPORTING LIMIT REQUIREMENTS

Table 12-1 lists the reporting limits for the comprehensive list of analytical constituents potentially monitored in Caltrans projects. The reporting limit is the minimum concentration at which the analytical laboratory can reliably report detectable values. This operational definition does not distinguish between the type of reporting limit, but relies on the laboratory's historical practice of reporting and a thorough review of laboratory practice and performance. Definitions of specific types of reporting limits (MDL, PQL, ML, etc.) can be found in the glossary to this document. The reporting

limits in Table 12-1 are provided as a guide for monitoring projects that do not have historical data sets for reference.

It is important to ensure that the RLs derived for the project are low enough to provide useful results. For example, if the analytical results are to be compared with water quality objectives (WQOs) every effort should be made to ensure that the RLs are lower. Therefore, the selected analytical methods should provide RLs at or below the criteria against which the stormwater samples are to be compared.

RLs are often specific to a given type of sample matrix. The RL for a given sample may be elevated due to the presence of interfering compounds. For example, RLs for metals in salt water are generally five to ten times higher than RLs for fresh water (when using the same method), due to salt interference with the atomic absorption instrument.

➢ ANALYTICAL METHODS

This section discusses the analytical methods that should be used to meet the reporting limits and other DQOs for the project (***Section 2*** describes how project DQOs are developed). As discussed in ***Section 4***, analytical constituents are selected based on regulatory and legal requirements, water quality objectives, historical data, and other considerations.

For some constituents, alternative analytical methodologies may be used to meet the data quality objectives for reporting limits and control limits of QC samples. Also, methods are being updated and new methods developed for different analytical parameters. In selecting the analytical method to be used, the following questions should be addressed:

- Does the method conform to any legal or regulatory requirements for the monitoring program?
- Does the method allow the required reporting limits to be easily obtained on stormwater samples?
- Does the method have the same or more stringent control limits for QA/QC samples?
- Will the data provided by the method be comparable to historical data collected at the station?
- Is the method recognized as "standard" so that the data collected at a station can be compared to other stations?
- Is the laboratory proficient with the method? Do they have historical data to show proficiency?

The recommended analytical methods for conventional, nutrient, metal, organic and bacteriological constituents are discussed below and are shown in Table 12-1. All of these methods are described either in "Standard Methods for the Examination of Water and Wastewater, 20th Edition" (APHA, *et al.*, 1998) or in the listed EPA method. A

complete list of the constituents in each EPA method is included in the Data Reporting Protocols (see ***Appendix H***) and also available on CD-ROM (Methods and Guidance for Analysis of Water – EPA 821-C-99-004). The 8000 series analyses (modified soils methods) can be downloaded from the Internet at "http://www.epa.gov/SW-846/8xxx.htm". The approved methods should be referenced for more detailed sampling and analytical information.

Conventional Parameters

Typical conventional parameters analyzed by the laboratory include hardness, total dissolved solids (TDS), total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and turbidity. Specific conductance, temperature, and pH are measured and recorded in the field using appropriate field instruments when each sample is collected.

Total hardness, expressed as the concentration of calcium carbonate, is a titrimetric-colorimetric method of sequestering the calcium and magnesium ions in the stormwater sample, as described by EPA Method 130.2. Total dissolved solids (also described as filterable residue), described in EPA Method 160.1, is measured by evaporating the filtrate from a previously filtered stormwater sample and weighing the remaining solids. TSS is measured by filtering the stormwater sample and recording the increase in filter weight, as described by EPA Method 160.2. The recommended RLs for these methods are listed in Table 12-1.

BOD measures the dissolved oxygen consumed by microbial life in the stormwater sample using a probe or bottle technique, as currently described by Standard Method 5210B. COD measures the amount of oxygen required by a strong chemical oxidizing agent to oxidize the organic matter in a sample. COD is measured using EPA Method 410.1. Turbidity is a measure of how much light a stormwater sample will scatter; highly turbid (cloudy) samples will scatter more light than clear samples. The measurement of turbidity is accomplished using EPA Method 180.1.

Nutrients

Typical nutrient constituents analyzed include nitrite (as N), nitrate (as N), ammonia (as N), total Kjeldahl nitrogen (TKN), total phosphorus, and orthophosphate. Nitrite and nitrate are determined in stormwater samples using EPA Method 300.0 (ion chromatography) and are expressed as the concentration of nitrogen. Ammonia is measured with an ion-specific electrode described in Method 350.3 and expressed as the concentration of nitrogen. TKN is typically measured using EPA Method 351.3, in which ammonia is determined after distillation by titrimetric, colorimetric, or potentiometric procedures. Phosphorus is measured in all forms (total, dissolved, and soluble reactive phosphorus) by a colorimetric procedure described in EPA Method 365.2.

Metals

Metals analysis typically includes the total recoverable and dissolved fractions. If composite sampling procedures are used, the laboratory will filter an aliquot of the stormwater sample for analysis of the dissolved metals and add preservatives to both the total and dissolved subsamples.

There are several methods available for metals analysis. The EPA methods commonly in use are inductively coupled plasma (ICP), graphite furnace atomic absorption (GF-AA), and inductively coupled plasma mass spectrometry (ICP-MS). These methods may be used individually or in concert to meet the DQOs of the project.

Analysis should be performed for metals using (except mercury; see below) GF-AA (EPA method 200.9) or ICP-MS (EPA method 200.8). The GF-AA and ICP-MS methods have significantly lower reporting limits for most metals compared to the ICP, although the GF-AA and ICP-MS methods are more expensive that the ICP method. Caltrans stormwater samples should not be analyzed using ICP procedures currently described by EPA Method 200.7, because ICP reporting limits for several metals are often higher than their water quality criteria. However, many laboratories prefer to analyze the samples first using ICP to ensure that the metals concentrations are not too high for the more sensitive GF-AA or ICP-MS equipment.

EPA recently developed a new ICP-MS series (Method 1638) for metals analyses designed to yield very low reporting limits by using class 100 clean room practices and clean technique sampling. This method should be used if the reporting limits using EPA Method 200.8 are not sufficiently low enough to provide regular and reliable detection.

The recommended method for mercury analysis is cold vapor atomic fluorescence spectrometry (CVAFS, EPA Method 1631).

Organics

Total petroleum hydrocarbon (TPH) analyses for Caltrans monitoring projects will typically focus on gasoline, diesel, and motor oil hydrocarbons. Gasoline is in the carbon range between 5 and 10 carbons (C5 and C10) and requires volatile organic sampling techniques (grab sampled into VOA collection bottles with no headspace). The diesel range is typically considered from C12 to C24 and motor oil is approximately C24 to C36 or higher. EPA Method 8015 modified/extended is recommended for analysis of Caltrans' stormwater samples, because it distinguishes between the types of hydrocarbons present in the sample, and there is no concern of non-petroleum interferences. EPA Method 8015 mod/ext. also provides additional confidence in sample results because of the additional quality control/quality assurance procedures included with the method. Caltrans should specify to the analytical laboratory that the samples should be analyzed by EPA Method 8015 mod/ext. and quantified for the hydrocarbon range(s) of interest. The laboratory should review the chromatograms to ensure that the summary report of analytical results actually represents hydrocarbons which show a gas chromatographic trace similar to hydrocarbons range(s) of interest. The gas

chromatograms for the samples, QC samples, and standards can be requested in the data package.

Measurement of total oil and grease is accomplished using EPA Method 1664 and should also be included if the expected concentrations are above the reporting limit noted in Table 12-1. EPA method 413.1 uses freon as the carrier gas. Freon is no longer readily available and it is likewise difficult to find laboratories that can cost-effectively perform the analysis using this method.

Additional organic constituents that may be analyzed include polynuclear aromatic hydrocarbons (PAHs), pesticides, and solvents. PAHs can be measured using a gas chromatography/mass spectrometry method such as EPA Method 625 (for semi- and non-volatile organics). However, this method is prone to matrix interferences and elevated reporting limits. EPA Method 8310, which was also developed for water samples, detects the most toxic PAHs. The high selectivity of the detectors used for Method 8310 eliminates most matrix interferences and allows for very low reporting limits.

Analysis for the organophosphorus pesticides diazinon and chlorpyrifos should be performed according to EPA Method 8141 (organophosphorus compounds by gas chromatograph) or by enzyme-linked immunosorbant assay (ELISA) analysis.

Solvents may be occasionally detected in stormwater runoff from maintenance/vehicle service locations (LWA, 1996). Although the majority of these constituents are volatile organic compounds (which readily evaporate and are not expected to be found in stormwater runoff), their inclusion in Caltrans stormwater monitoring efforts may be important for characterization of runoff from maintenance yards. The best methods for analysis of solvent-related constituents are EPA Methods 601 and 602.

Fecal and Total Coliform Bacteria

Bacteriological constituents for analysis include fecal and total *coliform*. These analyses are typically performed using Standard Methods 9221B and 9221E, respectively, although other methods are available. This constituent has a short recommended holding time for analysis. Standard Methods specifies that these samples must be delivered to the laboratory within 6 hours of sampling and analysis begun by the laboratory within 2 hours of delivery (APHA, *et. al.,* 1998). This is interpreted as a maximum total holding time of eight hours prior to initiating analysis. Samples that do not meet holding time specifications should be qualified as described in ***Section 13***.

➢ LABORATORY DATA PACKAGE DELIVERABLES

As a part of the laboratory contract, the data package that will be delivered to Caltrans and the timing of its delivery (turn around time) should be defined. The data package should be delivered in hard copy and electronic copy (on diskette).

The hard copy data package should include a narrative that outlines any problems, corrections, anomalies, and conclusions, as well as completed chain of custody documentation. A summary of the following QA/QC elements must be in the data package: sample extract and analysis dates, results of method blanks, summary of analytical accuracy (matrix spike compound recoveries, blank spike compound recoveries, surrogate compound recoveries), summary of analytical precision (comparison of laboratory split results and matrix spike duplicate results, expressed as relative percent difference), and reporting limits. Because the laboratory must keep the backup documentation (raw data) for all data packages, raw data (often called Contract Laboratory Program (CLP) data packages) should not be requested. However, for all total petroleum hydrocarbon analyses, the gas chromatograms of station samples, QC samples, blanks, and standards should be requested, as described above.

In addition to the hard copy, an electronic copy of the data can be requested from the laboratory. The electronic copy includes all the information found in the hard copy data package, with the exception of TPH chromatograms. Data reporting and the standardized electronic format for Caltrans data submittals are discussed in ***Section 14***.

Common turn around times for laboratory data packages are two to three weeks for faxed data and three weeks to thirty days for hard copy and electronic copy. Receiving the faxed data quickly allows an early data review to identify any problems that may be corrected through sample re-extraction or re-analysis. The hard copy data package should undergo data review as described in ***Section 13***.

Table 12-1. Analytical Constituent Method Specifications and Recommended Reporting Limits

Analyte	*Method Type*	*EPA Method Number [a]*	*Holding Time [b]*	*Container Type*	*Preservation*	*Reporting Limit/ Resolution*	*Units*
Conventionals							
BOD	probe	405.1; SM 5210B	24 hours [c]	glass or PE	4ūC	3	mg/L
COD	titrimetric; calorimetric	410.1; 410.4; SM 5220C; SM 5220D	28 days	glass or PE	4ūC and H_2SO_4 to pH<2	10	mg/L
Conductivity	conductivity meter	SM 2510	28 days	glass or PE	4ūC; filter if hold time > 24 hours	±1[d]	µmho/cm
Hardness	titrimetric; colorimetric; calculation	130.2; 130.1; SM 2340B	6 months	glass or PE	4ūC and HNO_3 or H_2SO4 to pH<2	2	mg/L
pH	electrometric	150.1	15 minutes	glass or PE	none	±0.1 [d,e]	std.units
Temperature	thermometer; thermistor; thermophone	SM 2550	15 minutes	glass or PE	none	±0.1[d]	ūC
TOC; DOC	oxidation or combustion	415.1	28 days	glass or PE[f]	4ūC and HCl or H_2SO_4 to pH<2 [g]	1	mg/L
TDS	dried filtrate weight	160.1	7 days	glass or PE	4ūC	1	mg/L
TSS	dried filter weight	160.2	7 days	glass or PE	4ūC	1	mg/L
Turbidity	nephelometric	180.1	48 hours	glass or PE	4ūC	±0.05[d]	NTU
Nutrients							
NH_3-N	titrimetric; potentiometric	350.2; 350.3	28 days	glass or PE	4ūC and H_2SO_4 to pH<2	0.1	mg/L
NO_3-N	ion chromatography	300.0	48 hours	glass or PE	4ūC	0.1	mg/L
NO_2-N	ion chromatography	300.0	48 hours	glass or PE	4ūC	0.1	mg/L
NO_3/NO_2-N	colorimetric	353.2	28 days	glass or PE	4ūC and H_2SO_4 to pH<2	0.1	mg/L
P	colorimetric	365.2	28 days	glass or PE	4ūC and H_2SO_4 to pH<2	0.03	mg/L
Ortho-P, dissolved	colorimetric	365.2; 365.3	48 hours	glass or PE	4ūC; filter immediately	0.03	mg/L
TKN	titrimetric; colorimetric; potentiometric	351.3	28 days	glass or PE	4ūC and H_2SO_4 to pH<2	0.1	mg/L
Metals							
Aluminum	GF-AA; ICP-MS	200.9; 200.8	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	25	µg/L
Arsenic	GH-AA; ICP-MS [k]	206.3; 200.8[l]	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	1	µg/L
Cadmium	GF-AA[h]; ICP-MS	213.2; 200.8[j]	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	0.2	µg/L
Chromium	GF-AA[h]; ICP-MS	218.2; 200.8	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	1	µg/L
Copper	GF-AA[h]; ICP-MS	220.2; 200.8[j]	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	1	µg/L
Iron	GF-AA; colorimetric	200.9; SM 3500-Fe B	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	25	µg/L
Lead	GF-AA[h]; ICP-MS	239.2; 200.8[j]	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	1	µg/L
Nickel	GF-AA[h]; ICP-MS	249.2; 200.8[j]	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	2	µg/L
Selenium	GF-AA; GH-AA; ICP-MS [k]	200.9[m]; 270.3; 200.8[j]	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	2	µg/L
Silver	GF-AA[h]; ICP-MS	272.2; 200.8[j]	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	0.2	µg/L
Zinc	GF-AA[h]; ICP-MS	289.2; 200.8[j]	filter for dissolved fraction and preserve within 48 hours; 6 months to analysis	Teflon, PE, or borosilicate glass	4ūC and HNO_3 to pH<2 [g]	5	µg/L
Mercury	CV-AFS	1631	filter for dissolved fraction and preserve within 48 hours; 28 days	Teflon or glass	4ūC and 5 mL/L of pretested 12N HCl or 5 mL/L BrCl solution [g]	0.5	ng/L

Table 12-1. Analytical Constituent Method Specifications and Recommended Reporting Limits (continued)

Analyte	*Method Type*	*EPA Method Number*	*Holding Time*	*Container Type*	*Preservation*	*Reporting Limit*	*Units*
Total Petroleum Hydrocarbons							
TPH (gasoline)	GC	8015b	14 days	VOA	4ūC	50	µg/L
TPH (diesel)			extract - 7 days; analyze - 40 days	wide -mouth glass			
TPH (motor oil)							
Oil & Grease	gravimetric (HEM/SGT)	1664 [n]	28 days		4ūC and HCl or H_2SO_4 to pH<2	5	mg/L
Pesticides and Herbicides [o]							
Glyphosate	HPLC	547	14 days	amber glass	4ūC; sodium thiosulfate in the presence of chlorine	5	µg/L
OP Pesticides (esp. diazinon and chlorpyrifos)	GC; ELISA [p]	8141; ELISA [p]	extract - 7 days; analyze - 40 days			0.05 [p]	
OC Pesticides	GC	8081 [q]				0.05 -1.0	
Chlorinated Herbicides		8151 [r]				0.1-1.0 (Triclopyr)	
Carbamate Pesticides		8321 [s]				0.07 - 3.5	
Miscellaneous Organic Constituents [o]							
Semi-/Non-Volatiles (Base; Neutral and Acid Extractables)	GC-MS [t]	625; 8270	extract - 7 days; analyze - 40 days	amber glass	4ūC; sodium thiosulfate in presence of chlorine	0.05 to 0.25	µg/L
PAHs	HPLC-UV; fluorescence	8310				0.05	µg/L
Volatile Organics (Purgeables)	GC-MS	624; 8260	14 days	VOA		0.5 - 50	µg/L
Purgeable Halocarbons	GC	601					
Purgeable Aromatics		602			4ūC; sodium thiosulfate in presence of chlorine; HCl to pH=2		
Miscellaneous Constituents							
Cyanide	titrimetric; spectrophotometric	335.2	14 days	PE or glass	4ūC; sodium hydroxide to pH=12	3	µg/L
Bacteriological							
Fecal Coliform	multi-tube fermentation	SM 9221E	8 hours [u]	sterile glass or plastic	4ūC; sodium thiosulfate in presence of chlorine	2 min., 2E6 max.	MPN/100 mL
Total Coliform		SM 9221B					

Notes for Table 12-1

•List of acronyms can be found at the end of the glossary.

•The 18th edition of Standard Methods for the Examination of Water and Wastewater is the current legally-adopted version in the Code of Federal Regulations (CFR). However, the 20th edition provides additional guidance on certain key items. For this reason the 20th edition is referenced in this table as the best available guidance.

•All EPA 1600 series methods require equipment handling, bottle preparation, sample collection (grab or composite) and sample handling according to EPA method 1669 protocols.

[a] Equivalent Standard Method can be substituted.

[b] Holding time specified in EPA guidance or referenced in Standard Method for equivalent method.

[c] The legally-adopted CFR (§136.3, Table II) specifies a holding time of 48 hours. Standard Methods 20th Edition requires a 6-hour holding time except when the sampling location is distant from the laboratory, in which case 24 hours is the maximum holding time. For composite samples, the start time for the holding time is the end of the compositing period. The total composite time is limited to 24 hours. For the purposes of this manual, the 24-hour holding time from the end of the compositing period is assumed because stormwater samples are usually not collected in close proximity to the laboratory. The method also specifies that storage time and conditions should be stated along with the results on the lab report when the holding time exceeds 6 hours.

[d] Refers to the instrument resolution.

[e] Also report temperature at time of measurement.

[f] Sampling and storage of samples in glass bottles is preferable. Sampling and storage in plastic bottles such as conventional polyethylene and cubitainers is permissible if it is established that the containers do not contribute contaminating organics to the samples.

[g] Filter dissolved samples before preservation.

[h] Where GF-AA is specified, method 200.9 is an acceptable alternative, except for zinc.

[i] Not used.

[j] EPA method 1638 is an additional available "clean-technique" ICP-MS method that can be used for this constituent. EPA method approval is in process.

[k] ICP-MS is prone to precision problems due to ionic interferences. ICP-MS is an acceptable method only if the sample matrix poses no significant interference problems.

[l] EPA method 1632 is an additional available "clean-technique" HG-AFS method that can be used for this constituent. EPA method approval is in process.

[m] EPA method 1639 is a "clean-technique" GF-AA method. EPA method approval is in process.

[n] Use of EPA Method 1664 for hexane extractable material with silica gel treatment (HEM/SGT) is designed to measure "non-polar material" and is the preferred analytical technique for Caltrans-related oil & grease analysis.

[o] See Appendix H or the EPA method for a complete list of constituents.

[p] For diazinon and chlorpyrifos.

[q] Must request special extraction and analysis for Oxadiazon.

[r] Must request special extraction and analysis for Triclopyr.

[s] Must request special extraction and analysis for Oryzalin.

[t] Can be modified with SIM detection, additional preconcentration, or with other techniques/modifications to meet performance criteria. Includes PAHs, phthalates, phenols, etc.

[u] The 8 hour hold time includes the 2 hour delivery and 6 hour set-up time allowances described in Standard Methods 20th edition. All efforts should be made to analyze samples within 6 hours of sampling to conform with the currently adopted edition of Standard Methods.

SECTION 13
QA/QC DATA EVALUATION

All data reported by the analytical laboratory must be carefully reviewed to determine whether the project's data quality acceptability limits or objectives (DQOs) have been met. This section describes a process for evaluation of all laboratory data, including the results of all QA/QC sample analysis.

Before any results are reported by the laboratory, the deliverable requirements should be clearly communicated to the laboratory, as described in the "Laboratory Data Package Deliverables" discussion in ***Section 12***.

The current section discusses QA/QC data evaluation in the following two parts:

KEY TOPICS

- **Initial Data Quality Screening**
- **Data Quality Evaluation**

The initial data quality screening identifies problems with laboratory reporting while they may still be corrected. When the data reports are received, they should be immediately checked for conformity to chain of custody requests to ensure that all requested analyses have been reported. The data are then evaluated for conformity to holding time requirements, conformity to reporting limit requests, analytical precision, analytical accuracy, and possible contamination during sampling and analysis. The data evaluation results in rejection, qualification, and narrative discussion of data points or the data as a whole. Qualification of data, other than rejection, does not necessary exclude use of the data for all applications. It is the decision of the data user, based on specifics of the data application, whether or not to include qualified data points.

➢ INITIAL DATA QUALITY SCREENING

The initial screening process identifies and corrects, when possible, inadvertent documentation or process errors introduced by the field crew or the laboratory. The initial data quality control screening should be applied using the following three-step process:

1. *Verification check between sampling and analysis plan (SAP), chain of custody forms, and laboratory data reports*: Chain of custody records should be compared with field logbooks and laboratory data reports to verify the accuracy of all sample identification and to ensure that all samples submitted for analysis have a value reported for each parameter requested. Any deviation from the SAP that has not yet been documented in the field notes or project records should be recorded and corrected if possible.

Sample representativeness should also be assessed in this step. The minimum acceptable storm capture parameters (number of aliquots and percent storm capture) per amount of rainfall are specified in ***Section 10***. Samples not meeting these criteria are generally not analyzed; however, selected analyses can be run at the Caltrans task manager's discretion. If samples not meeting the minimum sample representativeness criteria are analyzed, the resulting data should be rejected ("R") or qualified as estimated ("J"), depending upon whether the analyses were approved by Caltrans. Grab samples should be taken according to the timing protocols specified in the SAP. Deviations from the protocols will result in the rejection of the data for these samples or qualification of the data as estimated. The decision to reject a sample based on sample representativeness should be made prior to the submission of the sample to the laboratory, to avoid unnecessary analytical costs.

2. *Check of laboratory data report completeness*: As discussed in ***Section 12***, the end product of the laboratory analysis is a data report that should include a number of QA/QC results along with the environmental results. QA/QC sample results reported by the lab should include both analyses requested by the field crew (field blanks, field duplicates, lab duplicates and MS/MSD analysis), as well as internal laboratory QA/QC results (method blanks and laboratory control samples).

There are often differences among laboratories in terms of style and format of reporting. Therefore, it is prudent to request in advance that the laboratory conform to the style and format approved by Caltrans as shown in ***Section 14***. The Caltrans data reviewer should verify that the laboratory data package includes the following items:

- A narrative which outlines any problems, corrections, anomalies, and conclusions.
- Sample identification numbers.
- Sample extraction and analysis dates.
- Reporting limits for all analyses reported.
- Results of method blanks.
- Results of matrix spike and matrix spike duplicate analyses, including calculation of percent recovered and relative percent differences.
- Results of laboratory control sample analyses.
- Results of external reference standard analyses.
- Surrogate spike and blank spike analysis results for organic constituents.
- A summary of acceptable QA/QC criteria (RPD, spike recovery) used by the laboratory.

Items missing from this list should be requested from the laboratory.

3. *Check for typographical errors and apparent incongruities*: The laboratory reports should be reviewed to identify results that are outside the range of normally observed values. Any type of suspect result or apparent typographical error should be verified with the laboratory. An example of a unique value would be if a dissolved iron concentration has been reported lower than 500 μg/L for every storm event monitored at one location and then a value of 2500 μg/L is reported in a later event. This reported concentration of 2500 μg/L should be verified with the laboratory for correctness.

   Besides apparent out-of-range values, the indicators of potential laboratory reporting problems include:

   - Significant lack of agreement between analytical results reported for laboratory duplicates or field duplicates.
   - Consistent reporting of dissolved metals results higher than total or total recoverable metals.
   - Unusual numbers of detected values reported for blank sample analyses.
   - Inconsistency in sample identification/labeling.

   If the laboratory confirms a problem with the reported concentration, the corrected or recalculated result should be issued in an amended report, or if necessary the sample should be re-analyzed. If laboratory results are changed or other corrections are made by the laboratory, an amended laboratory report should be issued to update the project records.

➢ DATA QUALITY EVALUATION

The data quality evaluation process is structured to provide systematic checks to ensure that the reported data accurately represent the concentrations of constituents actually present in stormwater. Data evaluation can often identify sources of contamination in the sampling and analytical processes, as well as detect deficiencies in the laboratory analyses or errors in data reporting. Data quality evaluation allows monitoring data to be used in the proper context with the appropriate level of confidence.

QA/QC parameters that should be reviewed are classified into the following categories:

- ➢ Reporting limits
- ➢ Holding times
- ➢ Contamination check results (method, field, trip, and equipment blanks)
- ➢ Precision analysis results (laboratory, field, and matrix spike duplicates)
- ➢ Accuracy analysis results (matrix spikes, surrogate spikes, laboratory control samples, and external reference standards)

Each of these QA/QC parameters should be compared to data quality acceptability criteria, also known as the project's data quality objectives (DQOs). The key steps that should be adhered to in the analysis of each of these QA/QC parameters are:

1. Compile a complete set of the QA/QC results for the parameter being analyzed.
2. Compare the laboratory QA/QC results to accepted criteria (DQOs).
3. Compile any out-of-range values and report them to the laboratory for verification.
4. Prepare a report that tabulates the success rate for each QA/QC parameter analyzed.

This process should be applied to each of the QA/QC parameters as discussed below.

Reporting Limits

Stormwater quality monitoring program DQOs should contain a list of acceptable reporting limits that the lab is contractually obligated to adhere to, except in special cases of insufficient sample volume or matrix interference problems. The reporting limits used should ensure a high probability of detection. Table 12-1 provides recommended reporting limits for selected parameters.

Holding Times

Holding time represents the elapsed time between sample collection time and sample analysis time. Calculate the elapsed time between the sampling time and start of analysis, and compare this to the required holding time. For composite samples that are collected within 24-hours or less, the time of the final sample aliquot is considered the "sample collection time" for determining sample holding time. For analytes with critical holding times (≤48 hours), composite samples lasting longer than 24-hours require multiple bottle composite samples. Each of these composite samples should represent less than 24 hours of monitored flow, and subsamples from the composites should have been poured off and analyzed by the laboratory for those constituents with critical holding times (***see Section 12***). It is important to review sample holding times to ensure that analyses occurred within the time period that is generally accepted to maintain stable parameter concentrations. Table 12-1 contains the holding times for selected parameters. If holding times are exceeded, inaccurate concentrations or false negative results may be reported. Samples that exceed their holding time prior to analysis are qualified as "estimated", or may be rejected depending on the circumstances.

Contamination

Blank samples are used to identify the presence and potential source of sample contamination and are typically one of four types:

1. ***Method blanks*** are prepared and analyzed by the laboratory to identify laboratory contamination.

2. ***Field blanks*** are prepared by the field crew during sampling events and submitted to the laboratory to identify contamination occurring during the collection or the transport of environmental samples.
3. ***Equipment blanks*** are prepared by the field crew or laboratory prior to the monitoring season and used to identify contamination coming from sampling equipment (tubing, pumps, bailers, etc.).
4. ***Trip blanks*** are prepared by the laboratory, carried in the field, and then submitted to the laboratory to identify contamination in the transport and handling of volatile organics samples.
5. ***Filter blanks*** are prepared by field crew or lab technicians performing the sample filtration. Blank water is filtered in the same manner and at the same time as other environmental samples. Filter blanks are used to identify contamination from the filter or filtering process.

If no contamination is present, all blanks should be reported as "not detected" or "non-detect" (e.g., constituent concentrations should not be detected above the reporting limit). Blanks reporting detected concentrations ("hits") should be noted in the written QA/QC data summary prepared by the data reviewer. In the case that the laboratory reports hits on method blanks, a detailed review of raw laboratory data and procedures should be requested from the laboratory to identify any data reporting errors or contamination sources. When other types of blanks are reported above the reporting limit, a similar review should be requested along with a complete review of field procedures and sample handling. Often times it will also be necessary to refer to historical equipment blank results, corresponding method blank results, and field notes to identify contamination sources. This is a corrective and documentative step that should be done as soon as the hits are reported.

If the blank concentration exceeds the laboratory reporting limit, values reported for each associated environmental sample must be evaluated according to USEPA guidelines for data evaluations of organics and metals (USEPA, 1991; USEPA, 1995) as indicated in Table 13-1.

Table 13-1. USEPA Guidelines for Data Evaluation

Step	*Environmental Sample*	*Phthalates and other common contaminants*	*Other Organics*	*Metals*
1.	Sample > 10X blank concentration	No action	No action	No action
2.	Sample < 10X blank concentration	Report associated environmental results as "non-detect" at the reported environmental concentration.	No action	Results considered an "upper limit" of the true concentration (note contamination in data quality evaluation narrative).
3.	Sample < 5X blank concentration	Report associated environmental results as "non-detect" at the reported environmental concentration.	Report associated environmental results as "non-detect" at the reported environmental concentration.	Report associated environmental results as "non-detect" at the reported environmental concentration.

Specifically, if the concentration in the environmental sample is less than five times the concentration in the associated blank, the environmental sample result is considered, for reporting purposes, "not-detected" *at the environmental sample result concentration* (phthalate and other common contaminant results are considered non-detect if the environmental sample result is less than ten times the blank concentration). The laboratory reports are not altered in any way. The qualifications resulting from the data evaluation are made to the evaluator's data set for reporting and analysis purposes to account for the apparent contamination problem. For example, if dissolved copper is reported by the laboratory at 4 μg/L and an associated blank concentration for dissolved copper is reported at 1 μg/L, data qualification would be necessary. In the data reporting field of the database (see ***Section 14***), the dissolved copper result would be reported as 4 μg/L***)***, the numerical qualifier would be reported as "<", the reporting limit would be left as reported by the laboratory, and the value qualifier would be reported as "U" ("not detected above the reported environmental concentration").

When reported environmental concentrations are greater than five times (ten times for phthalates) the reported blank "hit" concentration, the environmental result is reported unqualified at the laboratory-reported concentration. For example, if dissolved copper is reported at 11 μg/L and an associated blank concentration for dissolved copper is reported at 1 μg/L, the dissolved copper result would still be reported as 11 μg/L.

Precision

Duplicate samples provide a measure of the data precision (reproducibility) attributable to sampling and analytical procedures. Precision can be calculated as the relative percent difference (RPD) in the following manner:

$$RPD_i = \frac{2 * |O_i - D_i|}{(O_i + D_i)} * 100\%$$

where:

RPD_i = Relative percent difference for compound i

O_i = Value of compound i in original sample

D_i = Value of compound i in duplicate sample

The resultant RPDs should be compared to the criteria specified in the project's DQOs. The DQO criteria shown in Table 13-2 below are based on the analytical method specifications and laboratory-supplied values. Project-specific DQOs should be developed with consideration to the analytical laboratory, the analytical method specifications, and the project objective. Table 13-2 should be used as a reference point as the least stringent set of DQO criteria for Caltrans monitoring projects.

Laboratory and Field Duplicates

Laboratory duplicates are samples that are split by the laboratory. Each half of the split sample is then analyzed and reported by the laboratory. A pair of field duplicates is two samples taken at the same time, in the same manner into two unique containers. Subsampling duplicates are two unique, ostensibly identical, samples taken from one composite bottle (see ***Section 10***). Laboratory duplicate results provide information regarding the variability inherent in the analytical process, and the reproducibility of analytical results. Field duplicate analysis measures both field and laboratory precision, therefore, it is expected that field duplicate results would exhibit greater variability than lab duplicate results. Subsampling duplicates are used as a substitute for field duplicates in some situations and are also an indicator of the variability introduced by the splitting process.

The RPDs resulting from analysis of both laboratory and field duplicates should be reviewed during data evaluation. Deviations from the specified limits, and the effect on reported data, should be noted and commented upon by the data reviewer. Laboratories typically have their own set of maximum allowable RPDs for laboratory duplicates based on their analytical history. In most cases these values are more stringent than those listed in Table 13-2. Note that the laboratory will only apply these maximum allowable RPDs to laboratory duplicates. In most cases field duplicates are submitted "blind" (with pseudonyms) to the laboratory.

Environmental samples associated with laboratory duplicate results greater than the maximum allowable RPD (when the numerical difference is greater than the reporting limit) are qualified as "J" (estimated). When the numerical difference is less than the RL, no qualification is necessary. Field duplicate RPDs are compared against the maximum

allowable RPDs used for laboratory duplicates to identify any pattern of problems with reproducibility of results. Any significant pattern of RPD exceedances for field duplicates should be noted in the data report narrative.

Corrective action should be taken to address field or laboratory procedures that are introducing the imprecision of results. The data reviewer can apply "J" (estimated) qualifiers to any data points if there is clear evidence of a field or laboratory bias issue that is not related to contamination. (Qualification based on contamination is assessed with blank samples.)

Laboratories should provide justification for any laboratory duplicate samples with RPDs greater than the maximum allowable value. In some cases, the laboratory will track and document such exceedances, however; in most cases it is the job of the data reviewer to locate these out-of-range RPDs. When asked to justify excessive RPD values for field duplicates, laboratories most often will cite sample splitting problems in the field. Irregularities should be included in the data reviewer's summary, and the laboratory's response should be retained to document laboratory performance, and to track potential chronic problems with laboratory analysis and reporting.

Accuracy

Accuracy is defined as the degree of agreement of a measurement to an accepted reference or true value. Accuracy is measured as the percent recovery (%R) of spike compound(s). Percent recovery of spikes is calculated in the following manner:

$$\%R = 100\% * [(C_s - C) / S]$$

where:

$\%R$ = percent recovery

C_s = spiked sample concentration

C = sample concentration for spiked matrices

S = concentration equivalent of spike added

Accuracy (%R) criteria for spike recoveries should be compared with the limits specified in the project DQOs. A list of typical acceptable recoveries is shown in Table 13-2. As in the case of maximum allowable RPDs, laboratories develop acceptable criteria for an allowable range of recovery percentages that may differ from the values listed in Table 13-2.

Percent recoveries should be reviewed during data evaluation, and deviations from the specified limits should be noted in the data reviewer's summary. Justification for out of range recoveries should be provided by the laboratory along with the laboratory reports, or in response to the data reviewer's summary.

<u>Laboratory Matrix Spike and Matrix Spike Duplicate Samples</u>

Evaluation of analytical accuracy and precision in environmental sample matrices is obtained through the analysis of laboratory matrix spike (MS) and matrix spike duplicate

(MSD) samples. A matrix spike is an environmental sample that is spiked with a known amount of the constituent being analyzed. A percent recovery can be calculated from the results of the spike analysis. A MSD is a duplicate of this analysis that is performed as a check on matrix recovery precision. MS and MSD results are used together to calculate RPD as with the duplicate samples. When MS/MSD results (%R and RPD) are outside the project specifications, as listed in Table 13-2, the associated environmental samples are qualified as "estimates due to matrix interference". Surrogate standards are added to all environmental and QC samples tested by gas chromatograph (GC) or gas chromatography-mass spectrometer (GC-MS). Surrogates are non-target compounds that are analytically similar to the analytes of interest. The surrogate compounds are spiked into the sample prior to the extraction or analysis. Surrogate recoveries will be evaluated with respect to the laboratory acceptance criteria to provide information on the extraction efficiency of every sample.

External Reference Standards

External reference standards (ERS) are artificial certified standards prepared by an external agency and added to a batch of samples. ERS's are not required for every batch of samples, and are often only run quarterly by laboratories. Some laboratories use ERS's in place of laboratory control spikes with every batch of samples. ERS results are assessed the same as laboratory control spikes for qualification purposes (see below). The external reference standards are evaluated in terms of accuracy, expressed as the percent recovery (comparison of the laboratory results with the certified concentrations). The laboratory should report all out-of-range values along with the environmental sample results. ERS values are qualified as biased high" when the ERS recovery exceeds the acceptable recovery range and "biased low" when the ERS recovery is smaller than the recovery range.

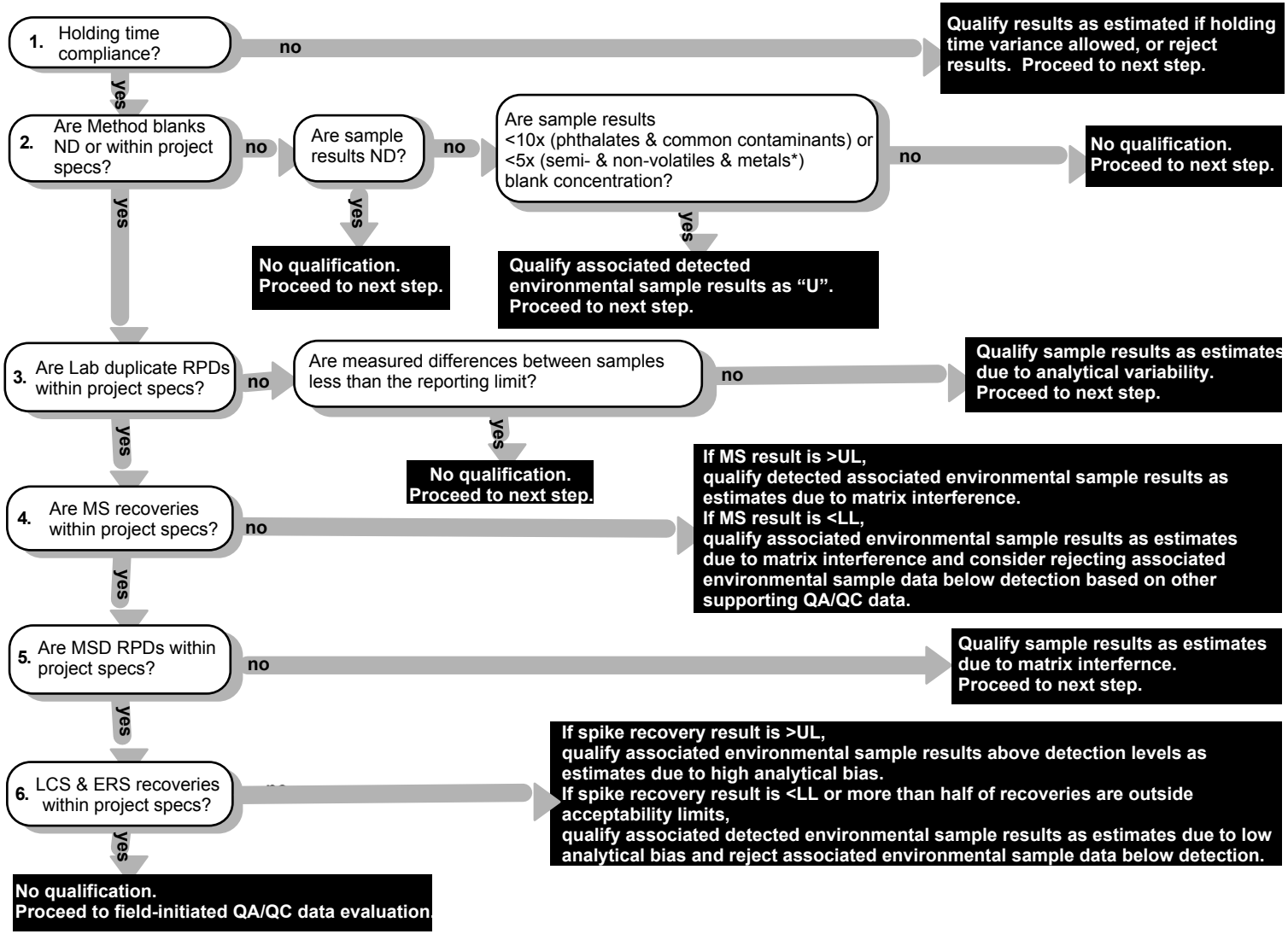
Laboratory Control Samples

LCS analysis is another batch check of recovery of a known standard solution that is used to assess the accuracy of the entire recovery process. LCSs are much like ERS's except that a certified standard is not necessarily used with LCSs, and the sample is prepared internally by the laboratory so the cost associated with preparing a LCS sample is much lower than the cost of ERS preparation. LCSs are reviewed for percent recovery within control limits provided by the laboratory. LCS out-of-range values are treated in the same manner as ERS out-of-range values. Because LCS and ERS analysis both check the entire recovery process, any irregularity in these results supersedes other accuracy-related qualification. Data are rejected due to low LCS recoveries when the associated environmental result is below the reporting limit.

A flow chart of the data evaluation process, presented on the following page as Figures 13-1 (lab-initiated QA/QC samples) and 13-2 (field initiated QA/QC), can be used as a general guideline for data evaluation. Boxes shaded black in Figures 13-1 and 13-2 designate final results of the QA/QC evaluation.

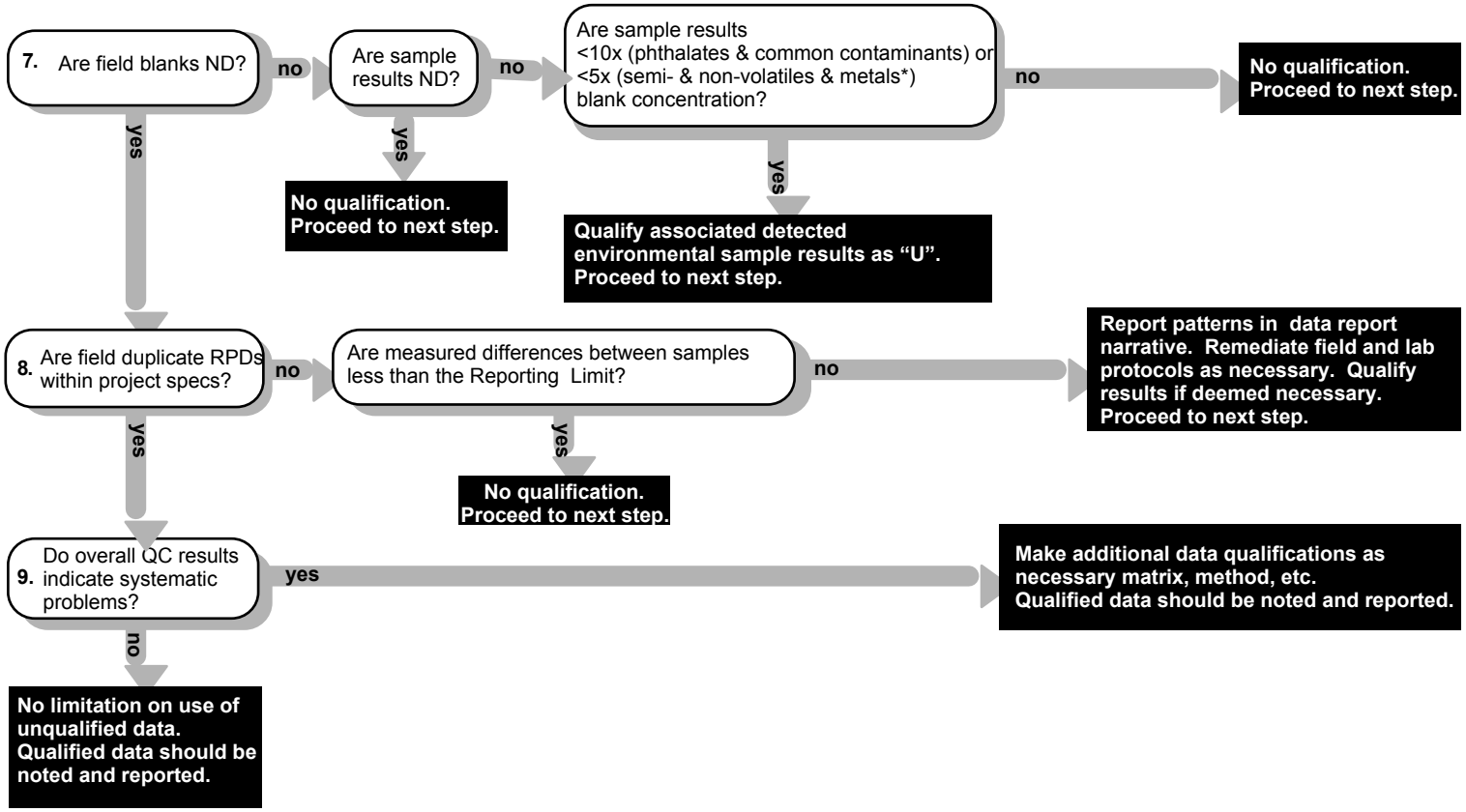
Table 13-2. Typical Control Limits for Precision and Accuracy for Analytical Constituents

Analyte	*EPA Method Number or Standard Method*	*Maximum Allowable RPD*	*Recovery Upper Limit*	*Recovery Lower Limit*
Conventionals				
BOD	405.1; SM 5210B	20%	80%	120%
COD	410.1; 410.4; SM 5220C; SM 5220D	20%	80%	120%
Hardness	130.2; 130.1; SM 2340B	20%	80%	120%
pH	150.1	20%	NA	NA
TOC/DOC	415.1	15%	85%	115%
TDS	160.1	20%	80%	120%
TSS	160.2	20%	80%	120%
Turbidity	180.1	20%	NA	NA
Nutrients				
NH3-N	350.2; 350.3	20%	80%	120%
NO3-N	300.0	20%	80%	120%
NO2-N	300.0	20%	80%	120%
NO3/NO2-N	353.2	20%	80%	120%
P	365.2	20%	80%	120%
Ortho-P	365.2; 365.3	20%	80%	120%
TKN	351.3	20%	80%	120%
Metals				
Ag	272.2; 200.8	20%	75%	125%
Al	200.9; 200.8	20%	75%	125%
Cd	213.2; 200.8	20%	75%	125%
Cr	218.2; 200.8	20%	75%	125%
Cu	220.2; 200.8	20%	75%	125%
Ni	249.2; 200.8	20%	75%	125%
Pb	239.2; 200.8	20%	75%	125%
Zn	289.2; 200.8	20%	75%	125%
As	206.3; 200.8	20%	75%	125%
Fe	200.9; SM 3500-Fe B	20%	75%	125%
Se	200.9; 270.3; 200.8	20%	75%	125%
Hg	1631	21%	79%	121%
Total Petroleum Hydrocarbons				
TPH (gasoline)	8015b	21%	45%	129%
TPH (diesel)		21%	45%	129%
TPH (motor oil)		21%	45%	129%
Oil & Grease	1664	18%	79%	114%
Pesticides and Herbicides				
Glyphosate	547	30%	70%	130%
OP Pesticides (esp. diazinon and chlorpyrifos)	8141; ELISA	25%	see method for constituent specific	
OC Pesticides	8081	25%		
Chlorinated Herbicides	8150; 8151	25%		
Carbamate Pesticides	8321	25%		
Miscellaneous Organic Constituents				
Base/Neutrals and Acids	625; 8270	30% to 50% (analyte dependent)	see method for constituent specific	
PAHs	8310			
Purgeables	624; 8260	20%		
Purgeable Halocarbons	601	30%	see method, Table 2	
Purgeable Aromatics	602	20%	see method for constituent specific	
Miscellaneous Constituents				
Cyanide	335.2	20%	75	125
Bacteriological				
Fecal Coliform	SM 9221E	-	-	-
Total Coliform	SM 9221B	-	-	-



*Environmental results between 5x and 10x the blank concentration are qualified as "an upper limit on the true concentration" and the data user should be cautioned.

Figure 13-1. Technical Data Evaluation for Lab-Initiated QA/QC Samples



*Environmental results between 5x and 10x the blank concentration are qualified as "an upper limit on the true concentration" and the data user should be cautioned.

Figure 13-2. Technical Data Evaluation for Field-Initiated QA/QC Samples

SECTION 14
DATA REPORTING PROTOCOLS

All data collected as part of a Caltrans Stormwater Monitoring project are entered into the Caltrans Statewide Stormwater Database. To facilitate data management, analysis, and the comparison of results from Caltrans Districts throughout the State, a uniform system for data reporting is required for all Caltrans monitoring projects. Every fall, and periodically each spring, Caltrans distributes a Data Reporting Protocols document that describes the manner in which data should be entered into the Database. The following key topics are covered in this section:

KEY TOPICS

- **General Instructions**
- **Organization of the Caltrans Statewide Stormwater Database**
- **List of Important Fields within the Database**
- **Certification Statement**

An overview of the most recent version (Caltrans, 1999c) of the Data Reporting Protocols (the Protocols) is provided in this section, and the entire document is included for reference in ***Appendix H***. A new version is expected in July 2000; no major revisions are anticipated. However, new data fields may be added, subject to the approval of Caltrans.

Following is a brief description of the Protocols, the organization of the document and an outline of the major reporting fields in the Caltrans Statewide Stormwater Database.

➢ GENERAL INSTRUCTIONS

Every monitoring site is assigned an ID number by Caltrans. At the beginning of each monitoring season, data reporters must contact the Caltrans database manager to receive the Site ID for each site to be sampled. Data reporters provide the name of the site, Caltrans District and constituents to be monitored. The database manager then supplies the appropriate Site IDs, or assigns them, if previously unmonitored sites are added to a project.

Standardized entries are provided for almost every field. These entries must be used exactly as presented in the Protocols (including for example specifications for spacing, hyphenation or capitalization), and attention must be given to the units specified for each constituent. If the standardized list does not contain an appropriate descriptor, the data reporter should contact the database manager prior to submitting any non-standardized entries.

The database manager will provide every data reporter with a data-reporting worksheet (Excel file format) in which all data must be submitted. All data fields should be included, even when they are left blank. Time series data (for example flow, precipitation, etc.) should be presented in a separate Excel worksheet, one for each site. For detailed instructions on how to include time series data, see ***Appendix H***.

For the reporting of dates and times, specific formats and references are dictated in the Protocols (Appendix H), as is a definition of a precipitation event. The purpose is to provide consistency in data reporting and calculation of summary statistics.

➢ ORGANIZATION OF THE CALTRANS STATEWIDE STORMWATER DATABASE

The database is separated into three parts: Sample Description, Sampling Event Description, and Site Descriptions. There are 29, 22 and 25 fields, respectively, in each of the sections. All three sections contain an Event ID and Monitoring Site ID field.

The Sample Description portion of the Database allows the data reporter to submit information that describes the sample itself: when and how it was collected, what it was analyzed for, the method and lab used to perform the analysis, and the result of the analysis. This section also allows the data reporter to characterize the sample source, as well as the portion of a rain event that is represented by the sample.

The second part of the Database contains data that describes the precipitation event itself. This includes when the rain started and stopped, rainfall intensity, when runoff started and ended, the total amount of rainfall prior to, and during, the event, and antecedent dry days.

In the third section of the Database, the data reporter enters records that describe the site at which the sample was obtained. The fields span a range of categories from geographic information and boundaries, such as coordinates, hydrologic sub-area, land use, and size of the watershed, to political data like county, Caltrans and RWQCB district.

➢ LIST OF IMPORTANT FIELDS WITHIN THE DATABASE

This section lists some of the fields in the Database. It is not meant to reproduce the Protocols, but simply to give the reader an idea of the type of information that is required from data reporters.

The Sample Description section includes such fields as Contract Number, Task Order Number, Constituent, Reported Value, Lab Name, Method Reference, Method Number, Method Detection Limit and Reported Detection Limit.

Also in this section is a heading for a Value Qualifier. This field qualifies reported values based on lab QA/QC (see ***Section 13*** and ***Appendix H***).

In the Sampling Event description section, the data reporter must enter in such information as the Rain Start Time, Rain End Time, Rain Start Date, Rain End Date, Event Rain, Max Intensity, Total Flow Volume, Peak Flow and the Estimated % Capture, as well as who collected the sample.

The Site Description portion is comprised of fields such as the Caltrans District, County, RWQCB, Latitude, Longitude, Land Use, Catchment Area, Impervious Fraction, Post Mile, Receiving Water Type, Time Series, and Site Description.

➢ CERTIFICATION STATEMENT

Caltrans stormwater monitoring reports shall include the certification statement shown in Figure 14-1. The certification statement must be signed by the contractor's project manager and task order manager or duly authorized representative, to verify that all data collection and reporting were completed in accordance with this Guidance Manual and any applicable project-specific sampling and analysis plans.

I certify that this document and all attachments were prepared by qualified personnel under my direction or supervision in accordance with the most recent version of the *Guidance Manual: Stormwater Monitoring Protocols* (Caltrans) and the **FILL IN (the project specific sampling and analysis plan)**.

Based on my inquiry of the person or persons directly responsible for gathering and reporting the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete

_____	_____
Consultant Project Manager	Date
_____	_____
Task Order Manager	Date

Figure 14-1. Certification Statement Required in All Caltrans Stormwater Monitoring Reports

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REFERENCES

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GLOSSARY

GLOSSARY

This glossary has been prepared to aid those readers of the guidance manual who may not be familiar with some of the terms used. Many of these terms are considered standard usage, with definitions that are well known and accepted, while others are newly coined, based on recent developments in the field. It should be noted that the purpose of this glossary is not to standardize terminology, but to allow readers to understand any unfamiliar words that may be encountered in the guidance manual.

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Accuracy

The closeness of a measured value to the true value. Accuracy is usually measured as the percent recovery of a matrix spike, which is then compared to the accuracy criteria specified in the data quality acceptance criteria or objectives (DQOs).

Aliquot

Individual, discrete sample volumes taken at set intervals (flow, time, or precipitation) or otherwise composited together to form a representative sample of a monitoring period flow.

Antecedent Moisture Conditions

The soil moisture conditions of the catchment or watershed at the beginning of a storm. These conditions affect the volume of runoff generated by a particular storm event.

Area-Velocity Flow Meter

A flow meter that combines the use of a velocity sensor with a depth-measurement device. The velocity sensor uses Doppler technology to measure average velocity throughout the flow stream. The depth measurement is converted to cross-sectional area of flow, using user-input channel or pipe geometry. The flow is then calculated automatically from the cross-sectional flow area and the velocity.

Base Flow

That part of the stream or surface water discharge that is not attributable to direct runoff from precipitation or snowmelt; it is usually sustained by water draining from natural storage in groundwater aquifers, lakes or wetlands.

Basin Plan

A water quality control plan developed by a Regional Water Quality Control Board (RWQCB) for a specific geographic area. It identifies beneficial uses of waters and the water quality objectives needed to maintain these beneficial uses.

Beneficial Uses

Uses of water that must be protected against water quality degradation. These uses, according to the California Porter-Cologne Water Quality Control Act, include domestic, municipal, agricultural and industrial supply; power generation; recreation; esthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves.

Best Available Technology Economically Achievable (BAT)

The minimum technology-based treatment applicable to toxic chemicals and other non-conventional pollutants (e.g., trash, temperature, color). For storm water from construction activities, Caltrans defines BAT as available and effective pollution control techniques that are generally applicable to construction sites. Deployment of a BAT on a given site is subject to a site-specific determination of feasibility.

Best Conventional Pollutant Control Technology (BCT)

The minimum technology-based treatment applicable to conventional constituents (total suspended solids, biochemical oxygen demand, etc.). For storm water from construction activities, Caltrans defines BCT as available and effective pollution control techniques that are generally applicable to construction sites. Deployment of a BCT on a given site is subject to a site-specific determination of feasibility.

Best Management Practice (BMP)

As used in this document, the term BMP refers to operational activities or physical controls to minimize or eliminate pollutants in storm water and non-storm water discharges from the storm drain system. Accordingly, the term BMP refers to both structural and nonstructural controls that have direct effects on the release, transport, or discharge of pollutants.

Blank Samples

Samples of contaminant-free blank water (see below) used to identify sample contamination during collection, handling, shipping, storage, laboratory handling and analysis. Blank samples can be collected at different points in the sampling/analysis process to identify sources of contamination.

Blank Water

Water provided by a manufacturer or laboratory that is free of detectable concentrations of the constituent of interest. This water is used for blank samples to identify potential sources of environmental sample contamination during the sampling/analytical process.

Bubbler (for water depth measuring)

A device in which depth of water flow is determined by measuring the pressure needed to force bubbles out of a line submerged in the flow stream.

Catch Basin

A storm drain inlet having a sump below the outlet to capture settled solids.

Catchment

A drainage basin from which surface runoff is channeled into a single outflow.

Clean Water Act (CWA)

The federal law that regulates the discharge of pollutants to waters of the U.S (most surface waters). The NPDES permit program implements the CWA. The CWA is also known as the Water Pollution Control Act Amendments. The California Water Code regulates discharges to groundwater (including discharges to the ground) and thus has wider jurisdiction.

Code of Federal Regulations (CFR)

Document that codifies all rules of the executive departments and agencies of the federal government. It is divided into fifty volumes, known as titles. Title 40 of the CFR (referenced as 40 CFR) lists all federal environmental regulations.

Composite Sample

A mixture of sample aliquots that forms one larger sample volume representative of a monitored flow.

Confidence Interval

The range of values that a statistical estimate is within for a specified probability

Confined Spaces

Storm sewers are classified as "confined spaces" under OSHA regulations. Regulations for entry into confined spaces are contained in 29 CFR 1910.146 and California Code of Regulation (CCR)-Title 8,-Article 108, confined spaces. The regulations require that no person shall enter a confined space without proper training and equipment. The risks associated with confined spaces include dangerous atmospheres, engulfment, falls, falling objects, and bodily harm due to explosion.

Constituent

A substance found in dissolved, colloidal, or particulate form in water that can be measured as a concentration.

Contaminant

A term often used interchangeably with "pollutant." A constituent that can cause harmful or objectionable conditions in water at certain concentrations.

Contamination (Sample)

A category of Quality Assurance/Quality Control (QA/QC) that is assessed by performing analyses on blank samples to identify sources of contamination that can occur during collection, handling, shipment, storage, laboratory handling and analysis.

Co-permittee

A permittee to a NPDES permit that is only responsible for permit conditions relating to the discharges from its area of jurisdiction.

Data Quality Objectives (DQOs)

Specify the quality of data required to support the specified objectives of the monitoring program. DQOs generally are used to determine the level of error considered to be acceptable in the data produced by the monitoring program; in large measure they are used to specify acceptable ranges of laboratory performance.

Detection Levels

Level of Quantitation (LOQ)

The constituent concentration that is sufficiently greater than a blank that it can be detected within specified levels by good laboratories during routine operating conditions.

Method Detection Limit (MDL)

The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. Concentrations reported by a laboratory that are between the MDL and RL (see below) are usually flagged by the laboratory as estimated "J," indicating the constituent is present but its concentration cannot be accurately quantified.

Minimum Level (ML)

The concentration of the lowest initial calibration standard that gives an acceptable calibration point.

Practical Quantitation Level (PQL)

The constituent concentration that can be determined within $\pm$ 20 percent of the true concentration by 75 percent of the analytical laboratories tested in a performance evaluation study. Alternatively, if performance data are not available, the PQL is 5 x MDL for carcinogens and 10 x MDL for non-carcinogens.

Reporting Limit (RL)

The lowest concentration of a constituent that can be reliably quantified within specified limits of precision and accuracy during routine laboratory operating conditions.

Drainage Swale

A storm drainage conveyance structure, usually grassed or paved, designed to intercept, divert, and convey surface runoff.

Duplicate Samples

Two samples taken at the same time from one location in order to assess precision.

Equipment Blanks

Blank samples that are collected by passing blank water (contaminant free) through clean equipment and analyzing for the desired constituents in order to assess source contamination from equipment.

Event Mean Concentration (EMC)

A parameter that describes the average concentration of a given constituent at a specific location during a storm event. The EMC should be representative of the complete runoff hydrograph, and is defined as the total constituent mass transported in the runoff, divided by the total runoff volume. The EMC is normally derived by analytical measurement of the constituent concentration in one or more representative composite samples.

Facility Pollution Prevention Plan (FPPP)

A plan which identifies the functional activities specific to the maintenance facility and the applicable BMPs and other procedures utilized by maintenance personnel to reduce the discharge of pollutants in storm water.

Field Blanks

Blank samples that are collected in the field using blank water (contaminant free) and the same methodologies used for sample collection. Field blanks are used to assess sample contamination due to sampling and sample processing activities.

First Flush

Typically referred to as the first 30 to 60 minutes or runoff from a rainfall event.

Flow-Proportional Composite Sample

A composite of multiple sample aliquots, each of which represents a predetermined flow volume. The sample aliquots is collected at flow volume intervals and combined in a manner that creates a larger volume sample representative of the entire monitored flow period. The principal advantages of flow-proportional composites (over time-proportional composites or grab samples) are that flow-proportional composites are not biased by over- or under-sampling any part of the hydrograph, and they allow direct estimation of Event Mean Concentration (EMC) and Event Mass Load (EML), without making assumptions about the shape of the hydrograph or the relationship between pollutant concentrations and flow rates.

Flume

A specially built reach of a channel (sometimes a prefabricated insert) that has a converging entrance, a throat section, and a diverging exit section. The throat area or slope (or both) of the flume is designed to differ from that of the channel, inducing a depth of flow which is proportional to flow rate. For each type of flume there is a functional relationship (mathematical equation) between depth and flow rate.

Grab Sample

An individual sample collected at one specific site at one point in time. Analysis of a grab sample provides a snapshot of stormwater quality at a point in time.

Hydrograph

A graph of flow versus time for a given point.

Hyetograph

A graph of rainfall to a catchment versus time.

Hydrologic Unit

A subunit of a basin as defined by a Regional Water Quality Control Board (RWQCB).

Illicit Discharge

Any discharge to a municipal storm sewer that is not composed entirely of stormwater. Discharges pursuant to a NPDES permit and those resulting from firefighting activities are exempted.

Infiltration

A complex process that allows runoff to penetrate the ground surface and flow through the upper soil surface.

Laboratory Control Sample

A clean matrix spiked with known concentrations of target analytes that is used to evaluate laboratory accuracy, independent of matrix effects.

Litter

Any man-made object that can be captured in a ¼-inch mesh. The definition does not include materials of natural origin such as soils, gravel and vegetative debris. Examples of litter items include cartons, wrappers, paper or plastic cups, cans napkins and cigarette butts.

Matrix Spike/Matrix Spike Duplicate

The laboratory process of splitting a stormwater sample into three aliquots, two of which are then "spiked" by adding known amounts of target constituents. The results of the analysis of the unspiked aliquot are compared to the spiked aliquots, and percent recovery of each spike is calculated in order to determine the accuracy of the analysis. The results of the two spiked aliquots are also compared to determine the precision of the analysis; this is accomplished by calculating the relative percent difference (RPD) between the spikes.

Method Blank

Contaminant free water that is taken through the entire analytical procedure and used to evaluate contamination from laboratory procedures or conditions.

Monitoring

Refers to a variety of activities and processes through which Caltrans will obtain information relevant to its implementation of the stormwater quality management program and to identify the need for and/or opportunities for revising or refining its program.

National Pollutant Discharge Elimination System (NPDES)

The national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits under the Clean Water Act.

Nonpoint Source Discharge

A discharge from a diffuse source that cannot be attributed to any particular discharge point (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet).

Non-Storm Water Discharge

Any discharge to a storm drain system or receiving water that is not comprised entirely of stormwater. Examples include process wastewaters, cooling water, and domestic wastewater discharges.

Oil and Grease

An analytical methodology that determines the concentration of groups of organic substances, primarily biological lipids and petroleum products, on the basis of their common solubility in an organic extracting solvent.

Oil Waste

Oil of any kind or in any form, including but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged soil.

Outfall

The point source where a municipal storm sewer discharges to receiving waters.

Overland Flow

The flow of water over the ground before it enters a defined channel.

Pathogen

A specific species of microorganism (a virus, bacteria, or protozoa) that can cause a communicable disease in the host organism.

Peak Flow

The maximum rate of flow passing a given point during or after a rainfall event or snowmelt.

Perennial Stream or Spring

A stream that flows continuously throughout the year in dry as well as wet years.

Permit

Refers to the National Pollutant Discharge Elimination System (NPDES) General Permit and is an authorization, license, or equivalent control document, issued by the U.S. Environmental Protection Agency (EPA) or an approved state agency, to implement the requirements of the NPDES.

Point Source

Any discernible, confined, and discrete conveyance or collection system, by which pollutants are or may be discharged. The term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

Pollutant

Any substance introduced into the environment that adversely affects the usefulness of a resource.

Pollutant Loading

The quantity of a pollutant found in runoff expressed in mass per unit of time. Pollutant loadings are commonly expressed in units of tons/year or pounds/year.

Precision

A measure of the degree of agreement among replicate analyses of a sample. Precision is usually assessed by calculating the relative percent difference (RPD) in duplicate samples and comparing it to RPD criteria specified in the data quality acceptance criteria or objectives (DQOs).

Pressure Transducer (for water depth measuring)

A device that measures the pressure of the liquid above a pressure sensor to determine the depth of the steam flow.

Quality Assurance (QA)

A definitive plan for sample collection and analysis that specifies the measures to be used to produce data of known quality.

Quality Control (QC)

A set of measures within sample collection and analysis methodology to assure that the methodology is in control to satisfy QA objectives.

Roughness Coefficient (n in Manning's equation)

A coefficient that is a measure of the physical characteristics influencing the flow of water across a surface.

Rainy Season

The Caltrans rainy season corresponds to the following dates:

- Northwestern California is defined as all of Caltrans District 1. Rainy season: October 1 through May 1.
- Northern California is defined as all of Caltrans Districts 2, 3, 4, 10 (except for those areas defined as Desert areas), and the Big Basin Hydrologic Unit in Caltrans District 5. Rainy season: October 15 through April 15.
- Southern California is defined as all of Caltrans Districts 5 (except for the Big Basin Hydrologic Unit), 6, 7, 8, 9, 11, and 12 except for those areas defined as Desert areas. Rainy season: November 1 through March 15.
- Desert areas are defined as the Colorado River Basin Regional Water Quality Control Board jurisdiction and the North and South Lahontan Regional Water Quality Control Board jurisdictions (excluding Mono and Antelope areas, East and West Walker River, East and West Carson River, Truckee and Little Truckee River hydrologic units). No rainy season is designated.

Receiving Waters

All surface waters (natural watercourse, lake, estuary or ocean) into which stormwater runoff is discharged.

Receiving Water Limitations

Permit limitations applied to dischargers to prevent violations of water quality standards.

Regional Water Quality Control Board (RWQCB)

The local agency responsible for the regulation of surface and ground water in California. The State Water Resources Control Board (SWRCB) sets overall policy that is implemented by the nine Regional Boards.

Runoff Volume

The volume of storm water that runs over the surface of the ground and into a storm drainage system and receiving water.

Site Runoff Coefficient (C)

A unitless coefficient used in the rational method that is ratio of the maximum rate of runoff to the uniform rate of rainfall times the watershed area.

Site Imperviousness

The fraction of land surface that does not allow infiltration of rainfall at the start of a rainfall event.

Split Samples

Samples that are split into two samples by the laboratory and each analyzed in order to assess laboratory precision. Also called laboratory duplicates, which is a misnomer.

State Water Resources Control Board (SWRCB)

As delegated by EPA, California agency that implements and enforces Clean Water Act Section 401(p) NPDES permit requirements, and is issuer and administrator of Caltrans NPDES Storm Water Permit. The State Water Resources Control Board (SWRCB) sets overall policy that is implemented by the nine Regional Water Quality Control Boards.

Statewide Storm Water Management Plan (SWMP)

The SWMP describes a program that is being implemented to reduce the discharge of pollutants associated with storm water drainage systems that serve highways and highway-related properties, facilities and activities. It describes how Caltrans will

comply with the provisions of National Pollutant Discharge Elimination System (NPDES) permit (Order No. 99-06-DWQ) (Permit) issued by the SWRCB on 15 July 1999.

Storm Drain Inlet

A drainage structure that collects surface runoff and conveys it to an underground storm drain system.

Stormwater Runoff

Runoff from rainfall or snowmelt that excludes infiltration and runoff from agricultural land.

Storm Water Advisory Teams (SWAT)

Caltrans teams with responsibility for evaluating new or modified storm water BMPs (Maintenance SWAT, Project Development SWAT, and Environmental Engineering SWAT).

Storm Water Management Practice

Any activities, prohibitions or modifications of practices, maintenance procedures, and other physical, structural and/or managerial practices to prevent or reduce stormwater pollution of receiving waters.

Storm Water Drainage System

Streets, gutters, inlets, conduits, natural or artificial drains, channels and watercourses, or other facilities that are used for the purpose of collecting, storing, transporting, or disposing of storm water.

Storm Water Pollution Prevention Plan (SWPPP)

A plan to identify water quality management practices to be implemented on all construction projects where construction activities result in disturbances of two hectares or more of land. This does not include (1) activities to maintain original line and grade, hydraulic capacity, or the original purpose of a facility, and (2) emergency construction activities to protect public health and safety are not covered under the Permit and do not require a SWPPP.

Storm Water Quality Task Force (SWQTF)

An ad hoc group, including staff from regulatory agencies, municipalities, industries, consultants and others, which meets bimonthly for information sharing and makes recommendations to the SWRCB regarding storm water management.

Subsamples

Volumes poured from a larger volume composite sample into individual constituent bottles.

Sump

In drainage, any low area that does not permit the escape of water by gravity flow.

Temporary Construction Site BMPs

BMPs temporarily used to address a short-term stormwater contamination threat.

Time of Concentration

The time required for water to flow from the most hydraulically remote point of the drainage area to the location being sampled, assuming uniform distribution of rainfall intensity throughout the area.

Total Maximum Daily Load (TMDL)

The maximum amount of a pollutant that a water body can assimilate and still meet ambient water quality standards. TMDLs are established for water quality-limited segments, which are defined as "any segment where it is known that water quality does not meet applicable water quality standards, and/or is not expected to meet applicable water quality standards, even after the application of technology-based effluent limitations..." (40 CFR 130.20). TMDLs are implemented through waste load allocations (WLA) applied to point sources and load allocation (LA) applied to non-point sources.

Total Petroleum Hydrocarbons (TPH)

Petroleum products of varying chain lengths of hydrocarbons that are classified in the following fractions (in increasing order of hydrocarbon chain length): BTEX (benzene, ethylbenzene, toluene, and xylene); kerosene; diesel; jet fuel; fuel oil; and lubricating oil. In order to quantify TPH concentrations in water samples, the different fractions must be analyzed for separately (eg., TPH-BTEX; TPH-Diesel; etc.).

Toxic Pollutants

Those pollutants defined in the federal regulations at 40 CFR 401.15 (pursuant to Section 307(a)(1) of the Clean Water Act). These pollutants include copper, lead, zinc, many chlorinated organic compounds including pesticides, and other constituents sometimes found in wastewater.

Transported Solids

Any object that can pass through a ¼-inch mesh and can fit into the sampler intake strainer at the end of the Teflon tubing.

Ultrasonic (for water depth measuring)

A device that measures depth by transmitting an ultra sound pulse from a sensor mounted above the stream and measuring the time for the echo to return from the flow stream surface. This measuring device must be placed in a secure location, where it will not be affected by wind, temperature flux, etc.

Uniform Flow

Flow in which the velocities are the same in both magnitude and direction from point to point along a conveyance; this can only occur in a channel of constant cross section, roughness, and slope in the direction of flow. The conditions for uniform flow must prevail in order to use Manning's equation for flow measurement.

Waste Load Allocation (WLA)

The maximum load of a given constituent each discharger is allowed to release into a particular waterway. A WLA is required for each specific constituent being regulated; the portion of a stream's total assimilation capacity assigned to an individual discharge.

Water Quality Objectives (WQO)

Numerical or narrative limits on constituents or characteristics of water designed to protect designated beneficial uses of the water. California's WQOs are established by the State and Regional Boards in the Water Quality Control Plans or Basin Plans.

Water Quality Parameter

A physical, chemical, or biological characteristic, property, or representation of the quality of water. The parameter may be stated in qualitative terms (for example, an aesthetic property such as the presence or absence of trash) or in quantitative terms (for example, the concentration of a constituent in water in mass per unit volume).

Water Quality Standards

A combination of the designated beneficial uses of water and water quality objectives (criteria) to protect those uses. Water quality standards are enforceable limits for the bodies of surface or ground waters for which they are established; they are promulgated by the State and Regional Boards in California.

Watershed

The drainage basin from which surface runoff is channeled into a single outflow (See catchment).

Water Pollution Control Program (WPCP)

A plan that must be prepared for all construction projects that do not require preparation of a SWPPP.

Weir

A device that has a crest and some side containment of known geometric shape, such as a V, trapezoid, or rectangle, and is used to measure flow rate in an open channel.

ACRONYMS

ACRONYMS

AC	alternating current
BMP	best management practice
BOD	biological oxygen demand
CCR	California Code of Regulation
CF	cubic feet
CFS	cubic feet per second
CLP	contract laboratory procedure
COC	chain-of-custody
COD	chemical oxygen demand DC
CSA	composite sample aliquots
CV-AA	cold vapor atomic absorption
CWA	Clean Water Act
DC	direct current
DI	deionized water
DOC	dissolved organic carbon
DQO	data quality objective
ELISA	enzyme-linked immunosorbant assay
EMC	event mean concentration
EML	event mass load
EPA	Environmental Protection Agency
ERS	external reference standards
GC-MS	gas chromatograph-mass spectrometry
GFAA	graphite furnace atomic absorption
GHAA	gaseous hydride atomic absorption
HPLC-UV	high performance liquid chromatography-ultra-violet detection
HSP	health and safety plan
ICP-MS	inductively coupled plasma-mass spectrometry
LCD	liquid crystal diode
LCS	laboratory control samples
LOS	line of sight
LWA	Larry Walker Associates
MDL	method detection limit
MPN	most probably number
MS/MSD	matrix spike/matrix spike duplicate

ND	not detected
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
OP	organophosphate pesticide
OSHA	Occupational Safety and Health Administration
PAHs	polynuclear aromatic hydrocarbons
PC	personal computer
PCBs	polychlorinated biphenyls
PQL	practical quantitation limits
QA	quality assurance
QC	quality control
QPF	quantity of precipitation forecast
RPD	relative percent difference
RL	reporting limit
SCVNSPCP	Santa Clara Valley Nonpoint Source Pollution Control Program
SM	standard methods
SOPs	standard operating procedures
SSOP	site-specific operating procedures
SWMP	Stormwater Management Program
TDS	total dissolved solids
TIE	toxicity identification evaluation
TKN	total kjeldahl nitrogen
TMDL	total maximum daily load
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRE	toxicity reduction evaluation
TRPH	total recoverable petroleum hydrocarbons
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
VSS	volatile suspended solids
WQC	water quality criteria

APPENDIX A

Monitoring Approaches

APPENDIX A
MONITORING APPROACHES

The purpose of this appendix is to put water quality constituent monitoring in context with other monitoring approaches, such as sediment chemistry monitoring, toxicity testing, use of biological indicators (for use in receiving water impact assessments), visual monitoring, and watershed monitoring. These other methods can be used to supplement water quality constituent monitoring, and many monitoring programs include a variety of approaches. The following discussion outlines the advantages, disadvantages, and applicability of these various approaches for monitoring of stormwater runoff from transportation-related facilities.

➢ WATER QUALITY CONSTITUENT MONITORING

Water quality constituent monitoring generally focuses on measurement of chemical parameters such as metals, organics, dissolved oxygen, nutrients, and physical parameters such as pH, suspended solids, and temperature. This type of monitoring usually involves sampling of stormwater in conveyance channels, detention and retention basins, stormwater outfalls or receiving waters during storm events. Such monitoring can have a variety of purposes, including: water quality characterization, compliance evaluation, estimating trends, or evaluating the effectiveness of pollution control measures.

Advantages

- Generally accepted sampling methods and protocols are already established.
- Historical databases are already established for water quality constituent monitoring. Existing databases on highway stormwater runoff quality would allow comparison between local and national data.
- Existing local databases can be used to assess whether water quality degradation has occurred over time (provided quality of the existing dataset is adequate).

Disadvantages

- Multiple sampling events at multiple stations are generally required to determine statistically significant trends or differences (this is expensive).
- Because of the highly variable nature of stormwater data, samples must be collected during a representative range of storm events to accurately characterize event mean concentrations.
- Requires accurate measure of storm flows and either costly automated sampling equipment or extensive manpower investment.
- Sampling may provide only a “snapshot" of what is occurring during a particular storm event.

➢ SEDIMENT CHEMISTRY MONITORING

Constituents found in stormwater runoff can become attached to sediments, settle to the bottom, and accumulate in slower moving receiving waters, detention and retention basins, and wetlands. The sediment can be analyzed for presence and mass of chemical constituents using laboratory methods in a manner similar to analyzing for constituents in water.

This type of monitoring is most suitable for evaluating conditions over the long-term as well as for evaluating the extent of localized impacts. Analysis of sediments provides a "time-integrated" picture of pollutant effects; thus, trends in sediment constituent concentrations can reveal long-term changes in pollutant loadings. By sampling along a linear transect at various distances from a suspected source or discharge location, constituent mass can be correlated with the distance from the source, revealing the extent of localized impacts. However, to determine if sediments are contaminated by anthropogenic sources, comparisons must generally be made to reference water bodies where sediment contamination from such sources has not occurred.

Advantages

- Generally accepted sampling methods and analysis protocols are already established.
- Impacts are generally localized; thus sources of constituents in the sediments can be more readily assessed. This work can be coordinated with water quality constituent monitoring to help determine sources of specific constituents of concern.
- Provides long-term, time-integrated indication of pollutant loading.
- Relatively easy to collect samples, particularly in shallow water bodies or under dry conditions.
- Sediment chemistry monitoring is considered a more direct measure of potential environmental effects to the benthic (bottom dwelling) community.

Disadvantages

- No sediment criteria or guidelines have been developed for California; thus, there are no guidelines for direct comparison of sediment pollutant concentrations. Sediment chemistry could be compared to guidelines developed by other states, although these are few, particularly for fresh water sediments.
- Method is useful only for constituents that attach to sediment particles (e.g. metals) and does not take the dissolved pollutant fraction into account.
- Because of resuspension and redistribution of sediments, sediment sampling is not useful as a real-time indicator of pollutant reduction measures.

- Requires numerous samples, both spatially and at various depths, to determine whether contamination comes from anthropogenic sources. May require years to acquire data sufficient for trend analysis.
- Concentrations of chemicals can be dependent on soil composition and particle size distribution (i.e., fine-grained sediments tend to sorb higher concentrations than coarse-grained sediments); thus, distribution of chemicals tends to be non-homogenous. This method requires careful study design and sample compositing schemes to obtain representative data.

➢ TOXICITY TESTING

Toxicity testing is used to assess potential impacts of stormwater constituents to aquatic systems. Testing in freshwater systems is usually conducted in the laboratory using species such as the water flea (*Ceriodaphnia dubia*) and fathead minnow (*Pimephales promelas*), although in situ testing could also be conducted. The test organisms are exposed to stormwater runoff samples for a pre-determined period of time (e.g., 7 days). The organisms are then assessed to determine if exposure to the sample produced lethal or sublethal effects including mortality, limited reproduction, or growth abnormalities. Behavioral changes (e.g., feeding, swimming) in response to exposure to the sample may also indicate the presence of constituents at toxic levels.

Acute toxicity tests focus on effects that are apparent over a short interval, usually 24 to 96 hours. Mortality is commonly the endpoint in these tests. Chronic tests focus on sublethal effects, such as reproduction and behavioral changes, apparent over a longer interval, usually seven days or more.

Toxicity identification evaluations (TIEs) can be conducted on samples that show acute toxicity in order to identify the probable cause of the observed toxicity. The TIE is a stepwise analytical procedure that first identifies the probable class of a toxicant (e.g., metals, organics), and eventually a specific toxicant. Once the toxicant or class of toxicants is known, control measures can be devised and implemented specifically for the toxicant.

Most current toxicity testing protocols were designed originally for use with continuous flow discharges (e.g., from wastewater treatment plants). This may limit the applicability of the methods to intermittent stormwater discharges. However, toxicity testing can be combined with general chemical constituent monitoring, because runoff sampling is similar for both types of testing. Toxicity testing can be viewed by the sampling crew as an additional "constituent" for analysis. This testing then simply requires additional sample volume.

Advantages

- A more direct measure of potential impacts to aquatic life than water quality or sediment chemistry monitoring.

- Generally accepted sampling and testing methods and protocols are already established.
- Toxicity testing can easily be incorporated into water quality constituent monitoring programs either at the outset, or on a tiered basis where water quality constituent monitoring has shown potential water quality degradation.
- There is a large amount of existing information on acute and chronic toxicity limits for various aquatic species.
- Identification of pollutants allows focusing of pollution reduction measures.

Disadvantages

- Laboratory toxicity testing conditions are not intended to simulate conditions found in the natural environment.
- Several possible factors, in addition to contaminant concentration and exposure time, can influence toxicity, including toxicant interactions, physical conditions (temperature, pH, etc.) and the organisms environmental conditioning or acclimation.
- The same test species may exhibit varying tolerance levels for different pollutants or combination of pollutants.
- There is some disagreement among practitioners as to what constitutes unacceptable aquatic impacts.

➢ BIOLOGICAL INDICATORS

This monitoring tool involves the evaluation of characteristics of biological populations to assess potential impacts to receiving waters. This group of methods may therefore be applicable only where discharges from Caltrans facilities combine with other discharges to create potential effects on biological assemblages in receiving waters

There are a number of biological methods that can be used in monitoring potential impacts to receiving waters from stormwater runoff. These include, but are not limited to, assessment of fish populations, benthic (bottom dwelling) invertebrate populations, monitoring of a single aquatic species as an indicator, or monitoring a composite of biological populations (e.g. fish species diversity, invertebrate indices, and algal communities). A wide array of indicators can be used to assess whether an impact has or is occurring. For example, assessment of fish populations can include measures of diversity of species, abundance of individual of a given species, prevalence of disease, and fish pathology (presence of tumors, fin damage, parasite infestations, etc.). Similar measures of species abundance and diversity can be used for invertebrate and algal populations.

Although assessment of biological indicators has the advantage of providing a direct measure of potential impacts to aquatic ecosystems, the use of biological indicators would generally have limited applicability as a monitoring tool for impacts from highway stormwater runoff on a statewide basis as this type of monitoring would be limited to areas where highway runoff directly enters natural water bodies supporting aquatic life.

Advantages

- Direct measure of impact to aquatic ecosystems.
- Fish, invertebrate, and algal species are relatively easy to collect and identify (Benthic invertebrates have limited mobility and may remain in an area throughout their lifespan. Thus, they may be a better indicator of a given area than fish, which move about freely).
- The environmental requirements and life history of many species are well documented.

Disadvantages

- Useful only in areas where highway runoff directly enters a natural water body.
- May be extremely difficult to separate impacts due to highway runoff from impacts due to other pollutant sources to a water body.
- May be extremely difficult to separate natural population and distribution changes from those caused by impacts from highway runoff.
- Requires the use of unimpacted reference sites with similar habitat and species types for comparison. It may be difficult to locate similar reference areas.

- Lack of species diversity in a given area may be due to confounding problems such as poor habitat, low flow, high water temperatures, fish barriers, or fishing pressure and may not be representative of impacts from runoff.
- Other tools (e.g. water quality constituent monitoring, toxicity testing) would still be necessary to more precisely characterize causes of degradation.
- Data collected may not be readily compared between regions due to differences in species, habitat types, etc.

➢ VISUAL MONITORING

Visual monitoring can provide useful information in understanding and interpreting stormwater quality results and may also help to identify potential sources of constituents of concern. Receiving water visual observations may include changes in stream flow characteristics, accelerated bank erosion, extensive algae growth, unusual color or odor, presence of floating solids, grease, oil, or foam. If the visual inspection suggests that physical conditions are not likely to be the sole cause of water quality problems or biological impacts, an assessment of surrounding land uses may help identify potential pollution sources.

Advantages

- May provide valuable information at a relatively low cost.
- Can be used in concert with other data (e.g., water quality, biological, sediment) to identify potential sources of adverse impacts.
- May provide insight for the modification of existing monitoring efforts.
- Visual observations made during dry weather may be extremely valuable. For example, illicit discharges to the storm drain system, which contribute to pollution of downstream receiving waters, can be identified.

Disadvantages

- There is a possibility that visual observations will not provide any valuable information or insight.
- Visually “clean” water does not always indicate good water quality, e.g. high or low pH water may appear “clean”.

➢ WATERSHED MONITORING

A watershed monitoring approach, that involves the pooling of stakeholders resources and expertise, can provide a better overall understanding of impacts and strategies for water quality improvement. Stakeholders may include representatives of local municipalities and districts, state and federal agencies, agriculture, industry, landowners, environmental organizations, universities, technical consultants, watershed conservancies, and the general public. Coordination among these stakeholders can lead to the development of a comprehensive monitoring program within the watershed to identify the causes, effects and extent of constituents of concern that affect the beneficial uses of water. The watershed monitoring effort can also measure progress as control strategies are implemented.

Advantages

- May provide a large cost savings over individual stakeholder monitoring and mitigation efforts.
- Redundant efforts can be avoided.
- Creates an opportunity for information sharing.
- Provides consistency in sample collection and analysis, which provides better data quality assurance and acceptance.

Disadvantages

- Stakeholders may have conflicting monitoring goals.
- Inflexibility may exist due to individual program constraints.
- Financial and other benefits may not be clear to all stakeholders.

APPENDIX B

Analytical Constituents: Descriptions, Data Summary, and Water Quality Objectives

APPENDIX B
ANALYTICAL CONSTITUENTS: DESCRIPTIONS, DATA SUMMARY, AND WATER QUALITY OBJECTIVES

This appendix contains a description of the constituents included in the Minimum Constituent List for Characterization, a summary of Caltrans runoff quality monitoring data compiled during 1997-03, and a summary of prevailing statewide water quality objectives.

Following is a brief description of the constituents listed in Table 4-1, Minimum Constituent List for Characterization. These constituents were selected based upon the rationale discussed in ***Section 4***.

➢ CONVENTIONAL CONSTITUENTS

Electrical Conductivity (EC). Electrical conductivity is a measure of the ability of water to carry an electric current. This ability depends on the presence of ions, their concentration, valence, mobility, and temperature. Most dissolved inorganic substances in water are in the ionized form and thus contribute to the conductivity of the water. Many organic compounds, however, do not ionize, or ionize only partially, and hence do not contribute as much to the conductivity measurement. EC measurements can give an estimate of the variations in the dissolved mineral content of stormwater in relation to receiving waters.

Total Hardness as $CaCO_3$. Total hardness is a measure of the concentration of divalent cations in water. In most natural waters total hardness is the sum of the concentrations of Ca^{2+} and Mg^{2+} ions expressed as mg/l $CaCO_3$. The toxicity of certain metals (see below) to aquatic organisms is inversely proportional to the total hardness concentration. As a result, numeric water quality standards for certain metals vary with the total hardness of the water.

pH. The pH, which is $-\log [H^+]$, is universally used to express the intensity of the acid or alkaline condition of a water sample. The pH of natural waters ranges between 6 and 9. Extremes of pH can have deleterious effects on aquatic systems. Also, the toxicity of ammonia to aquatic organisms is highly pH dependent.

Total Dissolved Solids (TDS). The dissolved solids in water consist of inorganic and organic molecules and ions that are in true solution. In fresh water the total dissolved solids concentration typically ranges from 20 to 1,000 mg/l; in seawater it ranges from 30,000 to 35,000 mg/l. Elevated levels of dissolved solids can deleteriously affect water quality in a number of ways, most often because of the increased concentration (and perhaps increased number) of constituents that may be toxic to aquatic organisms.

Total Suspended Solids (TSS). Solids can be present in the water column in a dissolved phase or a suspended phase (TSS). In general, suspended solids are considered a pollutant when they significantly exceed natural concentrations and have a detrimental effect on the beneficial uses designated for the receiving water.

Suspended solids can absorb and scatter sunlight, deleteriously affecting the zone where photosynthesis occurs and, ultimately, the availability of food for plankton eating organisms; the associated turbidity can also decrease sight-feeding. Suspended solids can also physically interfere with the respiratory and feeding systems of aquatic organisms. Depending on the size-distribution of the particles and the velocity of the water, a portion of the suspended solids load will settle out of the water column; these settled solids can disrupt biological communities by blanketing benthic habitats (including gravel spawning beds) or by physically changing the pattern of the channel, leading to changes in the hydraulic regime.

Metal ions and charged organic compounds can sorb to the surfaces of particles. Where contaminated particles settle out in calm water, and where the chemical and physical factors that affect pore-water chemistry are favorable, sediments can expose interstitial organisms to concentrations of pollutants considered deleterious to aquatic life.

The major sources of suspended solids for Caltrans Districts include natural erosion, runoff from construction sites and other operations where the surface of the ground is disturbed. In addition, increased discharge volumes, as a result of developing impervious surfaces can accelerate the process of channel erosion, which in turn can increase total suspended (and dissolved) solids in runoff.

Temperature. Temperature must be known to determine the impact of ammonia toxicity in water. Water quality criteria for ammonia for the protection of freshwater aquatic life varies with temperature and pH. In general, un-ionized ammonia is most toxic to sensitive coldwater species at pH levels between 6.5 and 6.8 with corresponding temperatures between 0 and 5°C. Total ammonia is most toxic to sensitive coldwater species at pH levels between 8.8 and 9.0 with corresponding temperatures between 25 and 30°C.

TOC/DOC. Total Organic Carbon/Dissolved Organic Carbon are general indicators of the organic content of a sample. They also serve as correction factors for water quality objectives, in the same manner that hardness is used as a correction factor for metals criteria.

➢ NUTRIENTS

Excessive inputs of nutrients such as nitrogen and phosphorus to receiving waters can over-stimulate the growth of aquatic plants (algae and vascular plants), which can cause numerous deleterious effects. Algae and vascular aquatic plants produce oxygen during the day via photosynthesis and consume oxygen during the night via respiration. The pH of the water is linked to this phenomenon through the carbonate cycle: the pH rises during the day when CO_2 is consumed for the photosynthetic production of plant tissue and falls at night when CO_2 is released by respiration. Algal blooms due to inputs of nitrogen or phosphorus can cause wide fluctuations in this dissolved oxygen and pH cycle during a 24 hour period, which can cause fish kills and mass mortality of benthic organisms. In addition, excessive algal and vascular plant growth can accelerate eutrophication, interfere with navigation, and cause unsightly conditions with reduced water clarity, odors, and diminished habitat for fish and shellfish.

Nutrients generally have more adverse effects in water bodies with slow flushing rates, such as slow moving streams and lakes. Also, nutrients associated with suspended solids in stormwater runoff that settle out may later be solubilized and cause problems that were not at first apparent.

Other trace nutrients, such as iron, are also needed for plant growth. In general, however, nitrogen and phosphorus are the nutrients of importance in aquatic environments.

Phosphorus. Phosphorus is taken up by algae and vascular aquatic plants and, when available in excess of the plant's immediate needs for metabolism and reproduction, can be stored in the cells. With bacterial decomposition of plant materials, relatively labile pools of phosphorus are later released and recycled within the biotic community. The refractory portion (i.e., compounds relatively resistant to biodegradation) tends to sink to the bottom, where it degrades slowly over time.

Sources of phosphorus that may impact highway runoff include tree leaves, lubricants, and natural sources such as the mineralized organic matter in soils.

Phosphorus is present in one of three forms in stormwater discharges as dissolved or particulate:

- Orthophosphate (PO_4^{3-})
- Polyphosphate ($P_6O_3^{3-}$, $P_3O_{10}^{5-}$, and $P_2O_7^{4-}$)
- Organic phosphorus

Analytical tests for the minimum constituent list include total phosphorus (TP), which is the sum of the dissolved and particulate orthophosphate, polyphosphate and organic phosphorus; and dissolved orthophosphate (Ortho-P). All forms of phosphorus should be reported in concentration units of the mass of elemental phosphorus detected per unit volume.

Nitrogen. Nitrogen can exist in various forms in the environment due to changes in its oxidation states. The principal forms of nitrogen are:

	Nitrogen Compound	Formula	Oxidation State
a.	Organic nitrogen	Organic-N	-3
b.	Ammonia	NH_3	-3
c.	Ammonium ion	NH_4^+	-3
d.	Nitrogen gas	N_2	0
e.	Nitrite ion	NO_2^{2-}	+3
f.	Nitrate ion	NO_3^-	+5

Transformation of the above nitrogen compounds can occur through several key mechanisms: fixation, ammonification, synthesis, nitrification, and denitrification (Sawyer et al., 1994, Kayhanian and Tchbanoglous, 1998). Nitrogen fixation is the conversion of nitrogen gas into nitrogen compounds that can be assimilated by plants; biological fixation is the most common, but fixation can also occur by lightning, and through industrial processes. Ammonification is the biochemical degradation of organic-N into NH_3 or NH_4^+ by heterotrophic bacteria under aerobic or anaerobic conditions. Synthesis is the biochemical mechanism in which NH_4^+-N or NO_3^--N is converted into plant protein (Organic-N); nitrogen fixation is also a unique form of synthesis that can only be performed by nitrogen-fixing bacteria. Nitrification is the biological oxidation of NH_4^+ to NO_3^- through a two-step autotrophic process by the bacteria *Nitrosomonas* and *Nitrobacter*; the two-step reactions are usually very rapid and hence it is rare to find nitrite levels higher than 1.0 mg/l in water. The nitrate formed by nitrification is, in the nitrogen cycle, used by plants as a nitrogen source (synthesis) or reduced to N_2 gas through the process of denitrification; NO_3^- can be reduced, under anoxic conditions, to N_2 gas through heterotrophic biological denitrification.

Potential sources of nitrogen in highway runoff include atmospheric fallout, nitrite discharges from automobile exhausts, fertilizer runoff, and natural sources such as mineralized soil organic matter (Fraser and Cass, 1998).

Nitrogen is typically present in one of three forms in stormwater discharges:

- Oxidized inorganic forms, nitrate- plus nitrite-nitrogen (NO_3^--N, NO_2^--N)
- Reduced inorganic form, ammonia/ammonium-nitrogen (NH_3/NH_4^+-N)
- Reduced organic form, organic nitrogen (Org-N)

Analytical tests for the minimum constituent list include NH_3/NH_4^+-N, NO_3^--N, and Total Kjeldahl Nitrogen (TKN). TKN is a measure of NH_3/NH_4^+-N plus organic-N; the concentration of organic-N is thus obtained by subtracting the concentration of

NH_3/NH_4^+-N found in the sample from that of the TKN value. All forms of nitrogen should be reported in units of the mass of elemental nitrogen detected per unit volume.

➢ METALS (TOTAL AND DISSOLVED)

Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Zinc **(As, Cd, Cr, Cu, Ni, Pb, Zn).** Trace quantities of many metals are necessary for biological growth. Most metals, however, have numeric water quality standards because of their toxicity to aquatic organisms at high concentrations. The monitoring of metals is very important to control their potential deleterious effects on the beneficial uses of receiving waters.

Metals exist in stormwater runoff in the dissolved phase and adsorbed to suspended solids. Information regarding the partitioning of metals between the dissolved and particulate phase is important for selecting control measures. For example, if a large portion of total metals exist in the particulate phase, it may be possible to remove them through sedimentation or filtration. For this reason metals should always be analyzed for both the total and dissolved fractions.

Possible sources of metals in highway runoff include the combustion of fossil fuels, weathering of automotive tires and brake pads, and the corrosion of metals, paints, and solder. Metals can also reach receiving waters through the natural weathering of rock and soil erosion

As described above, the toxicity of some metals is inversely related to water hardness. The numeric water quality standards for cadmium, chromium, copper, lead, nickel, silver, and zinc are hardness-dependent. Copper, lead, and zinc are the metals most commonly found in highway runoff.

➢ DATA SUMMARY

Table B-1 contains a summary of all Caltrans runoff monitoring data compiled in the Caltrans Statewide Stormwater Database from monitoring conducted during the years 1997-03.

➢ WATER QUALITY OBJECTIVES

Table B-2 is comprised of a summary of the water quality objectives contained within the California Toxics Rule for inland surface waters and the California Ocean Plan for salt waters.

Table B-1. Data Reported in Caltrans Monitoring Projects 1997-2003.

Constituent	Fraction	# of Samples	Percent Detected	Reported Value Min Detected[1]	Reported Value Max Detected[1]	Units	Source
CONVENTIONALS							
BOD	N/A	46	69.6	2	49	mg/L	C, E, H, M
COD	N/A	1540	98.0	**2.41**	**8471**	mg/L	C, CGFF, E, H, M
DOC	N/A	2485	99.2	**0.94**	**1736**	mg/L	C, CG, CVIF, E, FF, H, M, P, R, TP
EC	N/A	3610	100.0	2.9	21000	µmhos/cm	C, CG, CVIF, E, FF, H, M, P, R, TP
Hardness as CaCO3	Total	3782	98.6	2	7520	mg/L	C, CG, CGFF, CVIF, E, FF, H, M, P, R, TP
pH	N/A	3689	100.0	3.50	11.40	pH units	C, CG, CGFF, CVIF, E, FF, H, M, P, R, TP
Salinity	N/A	9	100.0	0.02	0.25	mg/L	C, H
TDS	N/A	2347	97.4	2	12000	mg/L	all runoff characterization types
Temperature	N/A	642	100.0	**2**	**28.6**	°C	CG, CVIF, FF, H, M, P, R, TP
TOC	N/A	2468	99.7	0.60	550	mg/L	C, CG, CVIF, E, FF, H, M, P, R, TP
TSS	N/A	3841	99.2	1	40180	mg/L	all runoff characterization types
Turbidity	N/A	1481	100.0	**0.40**	16000	NTU	C, E, H, M, P
Turbidity, filtered	N/A	19	100.0	0.23	140	NTU	C
TVSS	N/A	334	97.3	2	928	mg/L	H
HYDROCARBONS							
Oil & Grease	N/A	1506	81.1	**0.59**	**226**	mg/L	C, CGFF, H, M
TEPH	N/A	13	61.5	**1.20**	20	mg/L	H
TPH (Diesel)	N/A	393	63.6	0.10	**43.4**	mg/L	CG, CGFF, FF, H, M, P
TPH (Gasoline)	N/A	373	0.0	ND	ND	mg/L	CG, FF, H, M, P
TPH (Heavy Oil)	N/A	196	81.1	**0.12**	**13**	mg/L	CG, E, FF, H, M, P
TPH (Jet Fuel)	N/A	13	0.0	ND	ND	mg/L	H
TPH (Kerosene)	N/A	13	0.0	ND	ND	mg/L	H
TPH (Motor Oil)	N/A	51	80.4	0.30	**23**	mg/L	CGFF, H, M, P
TPH (Stoddard Solvent)	N/A	13	0.0	ND	ND	mg/L	H
TRPH	N/A	192	23.4	**1**	**47**	mg/L	H, M
TVPH	N/A	13	7.7	0.13	0.13	mg/L	H
IONS							
Ca	Diss	7	100.0	8.99	494	mg/L	E
Ca	Total	102	94.1	4.10	601	mg/L	C, E, H
Cl	N/A	286	89.9	0.13	9000	mg/L	H
K	Diss	7	100.0	5.01	30.7	mg/L	E
K	Total	7	100.0	5.55	47.6	mg/L	E
Mg	Diss	7	100.0	0.8	16.9	mg/L	E
Mg	Total	110	74.6	0.74	1990	mg/L	C, E, H
Na	Diss	7	100.0	33.60	80.6	mg/L	E
Na	Total	19	89.5	1.30	104	mg/L	E, H
SO4	N/A	102	88.2	0.23	315	mg/L	E, H
METALS							
Ag	Diss	365	0.3	**2.1**	**2.1**	µg/L	C, E, H, M
Ag	Total	373	8.6	0.20	82	µg/L	C, E, H, M
Al	Diss	57	73.7	13	**2500**	µg/L	E, H
Al	Total	57	100.0	**230**	31430	µg/L	E, H
As	Diss	2153	46.2	**0.48**	81	µg/L	C, CG, CVIF, E, FF, H, M, P, R, TP
As	Total	2612	60.0	0.50	2300	µg/L	C, CG, CVIF, E, FF, H, M, P, R, TP
Be	Diss	14	0.0	ND	ND	µg/L	H
Be	Total	20	0.0	ND	ND	µg/L	H, M
Cd	Diss	3563	33.5	0.02	**19.45**	µg/L	C, CG, CVIF, E, FF, H, M, P, R, TP
Cd	Total	3614	67.0	0.11	**244**	µg/L	C, CG, CVIF, E, FF, H, M, P, R, TP
Cr	Diss	3631	74.3	**0.59**	141	µg/L	all runoff characterization types
Cr	Total	3684	95.6	1	1800	µg/L	all runoff characterization types
Cu	Diss	3748	96.8	1	**882**	µg/L	all runoff characterization types
Cu	Total	3853	97.6	1.03	9500	µg/L	all runoff characterization types
Fe	Diss	299	68.2	28	49900	µg/L	E, H, M
Fe	Total	344	95.6	25.2	240000	µg/L	E, H, M
Hg	Diss	121	11.6	**2.53**	1700	ng/L	CGFF, CVIF, E, H, M, P, TP
Hg	Total	134	24.6	**7.79**	2200	ng/L	CGFF, CVIF, E, H, M, P, TP

1. Bold Min Detected and Max Detected values reported from grab samples; non-bold values reported from composite samples.

Table B-1. Data Reported in Caltrans Monitoring Projects 1997-2003 (continued).

Constituent	Fraction	# of Samples	Percent Detected	Reported Value Min Detected[1]	Reported Value Max Detected[1]	Units	Source
METALS (continued)							
Ni	Diss	3592	73.5	0.59	**264**	µg/L	C, CG, CGFF, CVIF, E, FF, H, M, P, R, TP
Ni	Total	3697	91.3	**0.98**	2420	µg/L	C, CG, CGFF, CVIF, E, FF, H, M, P, R, TP
Pb	Diss	3751	50.9	0.20	480	µg/L	all runoff characterization types
Pb	Total	3854	91.5	0.52	2600	µg/L	all runoff characterization types
Sb	Diss	13	76.9	**1.20**	3.40	µg/L	H
Sb	Total	19	52.6	**1.30**	**29**	µg/L	H, M
Se	Diss	55	1.8	**0.14**	**0.14**	µg/L	H
Se	Total	61	1.6	**0.31**	**0.31**	µg/L	H, M
Tl	Diss	14	0.0	ND	ND	µg/L	H
Tl	Total	20	0.0	ND	ND	µg/L	H, M
V	Diss	17	70.6	1	6.20	µg/L	E
V	Total	17	100.0	4	273	µg/L	E
Zn	Diss	3750	96.8	1	**6041**	µg/L	all runoff characterization types
Zn	Total	3854	99.2	2.5	**6206**	µg/L	all runoff characterization types
MICROBIOLOGICALS							
Fecal Coliform	N/A	746	86.2	**2**	**205000**	MPN/100 mL	C, CGFF, H, M, P
Fecal Strep	N/A	47	89.4	62	**220000**	MPN/100 mL	C, H
Total Coliform	N/A	535	94.2	**2**	**900000**	MPN/100 mL	C, H, M
MINERALS							
Ba	Diss	17	100.0	0.002	0.01	mg/L	E
Ba	Total	17	100.0	0.007	0.81	mg/L	E
Chlorine Residual	N/A	21	38.1	1.10	17	mg/L	H
Mn	Diss	17	94.1	0.002	0.45	mg/L	E
Mn	Total	17	100.0	0.017	3.10	mg/L	E
MISCELLANEOUS CONSTITUENTS							
Cyanide	N/A	19	36.8	**0.008**	**0.017**	mg/L	H, M
Epicoprostanol	N/A	9	33.3	**0.26**	**1.05**	µg/L	H
Fecal Sterol	N/A	39	51.3	**0.05**	**4.64**	µg/L	H
NUTRIENTS							
NH3-N	Total	1718	91.7	**0.03**	**72.01**	mg/L	C, CGFF, E, H, M, P
NO2-N	N/A	1308	69.8	**0.01**	**14.74**	mg/L	C, CGFF, H, M
NO3-N	N/A	3774	93.9	0.01	**67.8**	mg/L	all runoff characterization types
Organic Nitrogen	N/A	53	94.3	0.15	9	mg/L	C, H
Ortho-P	Diss	2996	66.3	0.003	11	mg/L	C, CG, CVIF, E, FF, H, M, P, R, TP
Ortho-P	Total	287	29.3	0.04	6	mg/L	CGFF, E, H
P	Diss	1620	87.9	0.009	**15**	mg/L	C, CGFF, E, H, M
P	Total	3721	93.5	0.01	110	mg/L	C, CG, CGFF, CVIF, E, FF, H, M, P, R, TP
TKN	Total	3430	93.4	0.10	**161.3**	mg/L	C, CG, CGFF, CVIF, E, FF, H, M, P, R, TP
PCB'S							
Arochlor 1016	N/A	98	0.0	ND	ND	µg/L	C, H, M
Arochlor 1221	N/A	98	0.0	ND	ND	µg/L	C, H, M
Arochlor 1232	N/A	98	0.0	ND	ND	µg/L	C, H, M
Arochlor 1242	N/A	98	0.0	ND	ND	µg/L	C, H, M
Arochlor 1248	N/A	98	0.0	ND	ND	µg/L	C, H, M
Arochlor 1254	N/A	98	0.0	ND	ND	µg/L	C, H, M
Arochlor 1260	N/A	98	0.0	ND	ND	µg/L	C, H, M
PCBs (Total)	N/A	19	0.0	ND	ND	µg/L	H
PESTICIDES							
2,4,5-T	N/A	68	0.0	ND	ND	µg/L	C, H
2,4,5-TP (Silvex)	N/A	68	0.0	ND	ND	µg/L	C, H
2,4-D	N/A	68	0.0	ND	ND	µg/L	C, H
2,4-DB	N/A	68	0.0	ND	ND	µg/L	C, H
4,4'-DDD	N/A	98	0.0	ND	ND	µg/L	C, H, M
4,4'-DDE	N/A	98	0.0	ND	ND	µg/L	C, H, M
4,4'-DDT	N/A	108	0.9	0.12	0.12	µg/L	C, H, M

1. Bold Min Detected and Max Detected values reported from grab samples; non-bold values reported from composite samples.

Table B-1. Data Reported in Caltrans Monitoring Projects 1997-2003 (continued).

Constituent	Fraction	# of Samples	Percent Detected	Reported Value Min Detected[1]	Reported Value Max Detected[1]	Units	Source
PESTICIDES (continued)							
Alachlor	N/A	2	0.0	ND	ND	µg/L	H
Aldrin	N/A	98	0.0	ND	ND	µg/L	C, H, M
alpha-BHC	N/A	98	0.0	ND	ND	µg/L	C, H, M
alpha-Chlordane	N/A	21	0.0	ND	ND	µg/L	H, M
alpha-Endosulfan	N/A	98	0.0	ND	ND	µg/L	C, H, M
Atrazine	N/A	78	0.0	ND	ND	µg/L	C, H
Azinphos methyl	N/A	54	0.0	ND	ND	µg/L	H, M
beta-BHC	N/A	98	0.0	ND	ND	µg/L	C, H, M
beta-Endosulfan	N/A	98	0.0	ND	ND	µg/L	C, H, M
Bolstar (Sulprofos)	N/A	54	0.0	ND	ND	µg/L	H, M
Bromacil	N/A	33	18.2	**0.80**	**3**	µg/L	H
Chlordane	N/A	83	1.2	1.20	1.20	µg/L	C, H
Chlorpyrifos	N/A	371	23.2	0.03	0.97	µg/L	C, H, M
Chlorsulfuron	N/A	26	0.0	ND	ND	µg/L	H
Coumaphos	N/A	54	0.0	ND	ND	µg/L	H, M
Dalapon	N/A	68	0.0	ND	ND	µg/L	C, H
delta-BHC	N/A	98	0.0	ND	ND	µg/L	C, H, M
Demeton-O and S	N/A	54	0.0	ND	ND	µg/L	H, M
Demeton-S	N/A	31	0.0	ND	ND	µg/L	H
Diazinon	N/A	448	48.9	0.014	2.40	µg/L	C, CVIF, H, M, P, TP
Dicamba	N/A	68	0.0	ND	ND	µg/L	C, H
Dichlorprop	N/A	68	0.0	ND	ND	µg/L	C, H
Dichlorvos	N/A	54	1.9	1.50	1.50	µg/L	H, M
Dieldrin	N/A	98	0.0	ND	ND	µg/L	C, H, M
Dimethoate	N/A	2	0.0	ND	ND	µg/L	H
Dinoseb (DNBP)	N/A	68	0.0	ND	ND	µg/L	C, H
Diquat	N/A	36	0.0	ND	ND	µg/L	H
Disulfoton	N/A	54	0.0	ND	ND	µg/L	H, M
Diuron	N/A	403	42.7	0.50	220	µg/L	CG, FF, H, R
Endosulfan Sulfate	N/A	98	1.0	0.12	0.12	µg/L	C, H, M
Endrin	N/A	98	0.0	ND	ND	µg/L	C, H, M
Endrin Aldehyde	N/A	98	0.0	ND	ND	µg/L	C, H, M
Ethoprop	N/A	54	0.0	ND	ND	µg/L	H, M
Fensulfothion	N/A	54	0.0	ND	ND	µg/L	H, M
Fenthion	N/A	54	0.0	ND	ND	µg/L	H, M
Fluazifop-p-butyl	N/A	25	0.0	ND	ND	µg/L	H
gamma-BHC	N/A	98	0.0	ND	ND	µg/L	C, H, M
gamma-Chlordane	N/A	25	0.0	ND	ND	µg/L	H, M
Glyphosate	N/A	416	56.5	5.10	**530**	µg/L	CG, FF, H, R
Heptachlor	N/A	98	1.0	0.02	0.02	µg/L	C, H, M
Heptachlor Epoxide	N/A	98	1.0	0.01	0.01	µg/L	C, H, M
Isoxaben	N/A	6	0.0	ND	ND	µg/L	H
Malathion	N/A	85	0.0	ND	ND	µg/L	C, H
MCPA	N/A	30	0.0	ND	ND	µg/L	H
MCPP	N/A	30	0.0	ND	ND	µg/L	H
Merphos	N/A	54	0.0	ND	ND	µg/L	H, M
Methoxychlor	N/A	98	0.0	ND	ND	µg/L	C, H, M
Metolachlor	N/A	76	0.0	ND	ND	µg/L	C, H
Mevinphos	N/A	23	0.0	ND	ND	µg/L	M
Mirex	N/A	63	0.0	ND	ND	µg/L	C, H
Molinate	N/A	2	0.0	ND	ND	µg/L	H
Naled	N/A	31	0.0	ND	ND	µg/L	H
Oryzalin	N/A	397	15.4	0.50	77.8	µg/L	CG, FF, H, R
Oxadiazon	N/A	402	9.0	0.04	18	µg/L	CG, FF, H, R
Oxamyl	N/A	7	0.0	ND	ND	µg/L	H
Oxyfluorfen	N/A	20	0.0	ND	ND	µg/L	H
Paraquat	N/A	28	0.0	ND	ND	µg/L	H
Parathion, methyl	N/A	54	0.0	ND	ND	µg/L	H, M
Phorate	N/A	54	0.0	ND	ND	µg/L	H, M
Prometon	N/A	76	0.0	ND	ND	µg/L	C, H

1. Bold Min Detected and Max Detected values reported from grab samples; non-bold values reported from composite samples.

Table B-1. Data Reported in Caltrans Monitoring Projects 1997-2003 (continued).

Constituent	Fraction	# of Samples	Percent Detected	Reported Value Min Detected[1]	Reported Value Max Detected[1]	Units	Source
PESTICIDES (continued)							
Prometryn	N/A	2	0.0	ND	ND	µg/L	H
Prowl	N/A	1	100.0	0.79	0.79	µg/L	H
Ronnel	N/A	54	0.0	ND	ND	µg/L	H, M
Simazine	N/A	87	2.3	**0.31**	1.20	µg/L	C, H
Stirophos (Tetrachlorvinphos)	N/A	54	0.0	ND	ND	µg/L	H, M
Sulfometuron-methyl	N/A	26	0.0	ND	ND	µg/L	H
Thiobencarb	N/A	2	0.0	ND	ND	µg/L	H
Tokuthion (Prothiofos)	N/A	54	0.0	ND	ND	µg/L	H, M
Toxaphene	N/A	98	0.0	ND	ND	µg/L	C, H, M
Trichloronate	N/A	54	0.0	ND	ND	µg/L	H, M
Triclopyr	N/A	206	6.3	0.30	830	µg/L	CG, FF, H, R
SEMI-VOLATILE ORGANIC COMPOUNDS							
1,2,4-Trichlorobenzene	N/A	110	0.0	ND	ND	µg/L	C, H, M
1,2-Diphenylhydrazine	N/A	91	0.0	ND	ND	µg/L	C, H, M
2,4,5-Trichlorophenol	N/A	83	0.0	ND	ND	µg/L	C, H, M
2,4,6-Trichlorophenol	N/A	84	0.0	ND	ND	µg/L	C, H, M
2,4-Dichlorophenol	N/A	84	0.0	ND	ND	µg/L	C, H, M
2,4-Dimethylphenol	N/A	84	0.0	ND	ND	µg/L	C, H, M
2,4-Dinitrophenol	N/A	84	0.0	ND	ND	µg/L	C, H, M
2,4-Dinitrotoluene	N/A	110	0.0	ND	ND	µg/L	C, H, M
2,6-Dinitrotoluene	N/A	110	0.0	ND	ND	µg/L	C, H, M
2-Chloronaphthalene	N/A	110	0.0	ND	ND	µg/L	C, H, M
2-Chlorophenol	N/A	84	0.0	ND	ND	µg/L	C, H, M
2-Methyl-4,6-Dinitrophenol	N/A	84	0.0	ND	ND	µg/L	C, H, M
2-Methylnaphthalene	N/A	109	0.0	ND	ND	µg/L	C, H, M
2-Methylphenol (o-Cresol)	N/A	64	0.0	ND	ND	µg/L	C, H, M
2-Nitroaniline	N/A	109	0.0	ND	ND	µg/L	C, H, M
2-Nitrophenol	N/A	84	0.0	ND	ND	µg/L	C, H, M
3,3'-Dichlorobenzidine	N/A	110	0.0	ND	ND	µg/L	C, H, M
3-Methyl-4-Chlorophenol	N/A	84	0.0	ND	ND	µg/L	C, H, M
3-Nitroaniline	N/A	109	0.0	ND	ND	µg/L	C, H, M
4-Bromophenyl Phenyl Ether	N/A	110	0.0	ND	ND	µg/L	C, H, M
4-Chloroaniline	N/A	109	0.0	ND	ND	µg/L	C, H, M
4-Chlorophenyl Phenyl Ether	N/A	110	0.0	ND	ND	µg/L	C, H, M
4-Methylphenol (p-Cresol)	N/A	83	1.2	**6.30**	**6.30**	µg/L	C, H, M
4-Nitroaniline	N/A	109	0.0	ND	ND	µg/L	C, H, M
4-Nitrophenol	N/A	84	0.0	ND	ND	µg/L	C, H, M
Acenaphthene	N/A	199	1.0	0.25	**0.72**	µg/L	C, H, M, P
Acenaphthylene	N/A	199	0.0	ND	ND	µg/L	C, H, M, P
Aniline	N/A	90	7.8	**5.70**	**24**	µg/L	C, H, M
Anthracene	N/A	199	0.0	ND	ND	µg/L	C, H, M, P
Benzidine	N/A	91	1.1	81	81	µg/L	C, H, M
Benzo(a)Anthracene	N/A	199	0.5	0.06	0.06	µg/L	C, H, M, P
Benzo(a)Pyrene	N/A	199	0.0	ND	ND	µg/L	C, H, M, P
Benzo(b)Fluoranthene	N/A	199	1.0	**0.04**	0.05	µg/L	C, H, M, P
Benzo(ghi)Perylene	N/A	199	3.0	0.05	0.17	µg/L	C, H, M, P
Benzo(k)Fluoranthene	N/A	199	0.0	ND	ND	µg/L	C, H, M, P
Benzoic acid	N/A	83	10.8	**32**	310	µg/L	C, H, M
Benzyl alcohol	N/A	83	1.2	**9.20**	**9.20**	µg/L	C, H, M
Bis(2-chloroethoxy)Methane	N/A	110	0.0	ND	ND	µg/L	C, H, M
Bis(2-chloroethyl)Ether	N/A	110	0.0	ND	ND	µg/L	C, H, M
Bis(2-chloroisopropyl)Ether	N/A	110	0.0	ND	ND	µg/L	C, H, M
Bis(2-Ethylhexyl)Phthalate	N/A	110	27.3	4.20	50	µg/L	C, H, M
Butylbenzyl Phthalate	N/A	110	0.0	ND	ND	µg/L	C, H, M
Carbazole	N/A	19	0.0	ND	ND	µg/L	H
Chrysene	N/A	199	0.0	ND	ND	µg/L	C, H, M, P
Dibenzo(a,h)Anthracene	N/A	199	0.0	ND	ND	µg/L	C, H, M, P

1. Bold Min Detected and Max Detected values reported from grab samples; non-bold values reported from composite samples.

Table B-1. Data Reported in Caltrans Monitoring Projects 1997-2003 (continued).

Constituent	Fraction	# of Samples	Percent Detected	Reported Value Min Detected[1]	Reported Value Max Detected[1]	Units	Source
SEMI-VOLATILE ORGANIC COMPOUNDS (continued)							
Dibenzofuran	N/A	109	0.0	ND	ND	µg/L	C, H, M
Diethyl Phthalate	N/A	110	0.0	ND	ND	µg/L	C, H, M
Dimethyl Phthalate	N/A	110	0.0	ND	ND	µg/L	C, H, M
Di-n-Butyl Phthalate	N/A	110	0.9	66	66	µg/L	C, H, M
Di-n-Octyl Phthalate	N/A	110	0.0	ND	ND	µg/L	C, H, M
Endrin Ketone	N/A	25	0.0	ND	ND	µg/L	H, M
Fluoranthene	N/A	199	3.0	0.05	0.1	µg/L	C, H, M, P
Fluorene	N/A	199	0.5	0.06	0.06	µg/L	C, H, M, P
Hexachlorobenzene	N/A	110	0.0	ND	ND	µg/L	C, H, M
Hexachlorobutadiene	N/A	110	0.0	ND	ND	µg/L	C, H, M
Hexachlorocyclopentadiene	N/A	110	0.0	ND	ND	µg/L	C, H, M
Hexachloroethane	N/A	110	0.0	ND	ND	µg/L	C, H, M
Indeno(1,2,3-c,d)Pyrene	N/A	199	0.0	ND	ND	µg/L	C, H, M, P
Isophorone	N/A	110	0.0	ND	ND	µg/L	C, H, M
Naphthalene	N/A	199	1.5	**0.88**	**3.50**	µg/L	C, H, M
Nitrobenzene	N/A	110	0.0	ND	ND	µg/L	C, H, M
N-Nitrosodimethylamine	N/A	91	0.0	ND	ND	µg/L	C, H, M
N-Nitrosodi-n-Propylamine	N/A	91	0.0	ND	ND	µg/L	C, H, M
N-Nitrosodiphenylamine	N/A	110	0.0	ND	ND	µg/L	C, H, M
Pentachlorophenol	N/A	84	0.0	ND	ND	µg/L	C, H, M
Phenanthrene	N/A	199	3.0	0.05	**0.37**	µg/L	C, H, M, P
Phenol	N/A	84	3.6	14	**29**	µg/L	C, H, M
Phenolics	N/A	38	36.8	10	**264**	µg/L	C, H, M
Pyrene	N/A	199	4.5	0.06	0.13	µg/L	C, H, M, P
VOLATILE ORGANIC COMPOUNDS							
1,1,1-Trichloroethane	N/A	17	0.0	ND	ND	µg/L	H
1,1,2,2-Tetrachloroethane	N/A	17	0.0	ND	ND	µg/L	H
1,1,2-Trichloroethane	N/A	17	0.0	ND	ND	µg/L	H
1,1-Dichloroethane	N/A	17	0.0	ND	ND	µg/L	H
1,1-Dichloroethylene	N/A	17	0.0	ND	ND	µg/L	H
1,2-Dichlorobenzene	N/A	114	0.0	ND	ND	µg/L	C, H, M
1,2-Dichloroethane	N/A	17	0.0	ND	ND	µg/L	H
1,2-Dichloropropane	N/A	17	0.0	ND	ND	µg/L	H
1,3-Dichlorobenzene	N/A	114	0.0	ND	ND	µg/L	C, H, M
1,4-Dichlorobenzene	N/A	114	0.0	ND	ND	µg/L	C, H, M
2-Butanone	N/A	17	11.8	**11**	**15**	µg/L	H
2-Chloroethylvinyl ether	N/A	11	0.0	ND	ND	µg/L	H
2-Hexanone	N/A	17	0.0	ND	ND	µg/L	H
4-Methyl-2-pentanone (MIBK)	N/A	17	0.0	ND	ND	µg/L	H
Acetone	N/A	17	64.7	**11**	**56**	µg/L	H
Acrolein	N/A	17	0.0	ND	ND	µg/L	H
Acrylonitrile	N/A	17	0.0	ND	ND	µg/L	H
Benzene	N/A	17	0.0	ND	ND	µg/L	H
Bromoform	N/A	17	0.0	ND	ND	µg/L	H
Carbon disulfide	N/A	17	5.9	**1.40**	**1.40**	µg/L	H
Carbon Tetrachloride	N/A	17	0.0	ND	ND	µg/L	H
Chlorobenzene	N/A	17	0.0	ND	ND	µg/L	H
Chlorodibromomethane	N/A	17	0.0	ND	ND	µg/L	H
Chloroethane	N/A	17	0.0	ND	ND	µg/L	H
Chloroform	N/A	17	0.0	ND	ND	µg/L	H
cis-1,2-Dichloroethene	N/A	17	0.0	ND	ND	µg/L	H
cis-1,3-Dichloropropene	N/A	17	0.0	ND	ND	µg/L	H
Dichlorobromomethane	N/A	17	0.0	ND	ND	µg/L	H
Dichlorodifluoromethane	N/A	17	0.0	ND	ND	µg/L	H
Ethylbenzene	N/A	17	0.0	ND	ND	µg/L	H
m,p-Xylenes	N/A	7	0.0	ND	ND	µg/L	H
Methyl Bromide	N/A	17	0.0	ND	ND	µg/L	H

1. Bold Min Detected and Max Detected values reported from grab samples; non-bold values reported from composite samples.

Table B-1. Data Reported in Caltrans Monitoring Projects 1997-2003 (continued).

Constituent	Fraction	# of Samples	Percent Detected	Reported Value Min Detected[1]	Reported Value Max Detected[1]	Units	Source
VOLATILE ORGANIC COMPOUNDS (continued)							
Methyl Chloride	N/A	17	0.0	ND	ND	µg/L	H
Methylene Chloride	N/A	17	17.6	**3.90**	**6.60**	µg/L	H
Methyl-t-butyl ether (MTBE)	N/A	45	4.4	**3.10**	**3.10**	µg/L	H
o-Xylene	N/A	17	0.0	ND	ND	µg/L	H
Pyridine	N/A	6	0.0	ND	ND	µg/L	H, M
Styrene	N/A	17	0.0	ND	ND	µg/L	H
Tetrachloroethylene (PCE)	N/A	17	0.0	ND	ND	µg/L	H
Tetrahydrofuran	N/A	17	0.0	ND	ND	µg/L	H
Toluene	N/A	18	22.2	0.67	**3**	µg/L	H, M
trans-1,2-Dichloroethene	N/A	17	0.0	ND	ND	µg/L	H
trans-1,3-Dichloropropene	N/A	17	0.0	ND	ND	µg/L	H
Trichloroethylene (TCE)	N/A	17	0.0	ND	ND	µg/L	H
Trichlorofluoromethane	N/A	17	0.0	ND	ND	µg/L	H
Vinyl acetate	N/A	17	0.0	ND	ND	µg/L	H
Vinyl chloride	N/A	17	0.0	ND	ND	µg/L	H
Xylenes (total)	N/A	10	0.0	ND	ND	µg/L	H

1. Bold Min Detected and Max Detected values reported from grab samples; non-bold values reported from composite samples.

Key to Reported Value:
ND = "not detected"

Key to Source (i.e., Runoff Characterization):
C = Construction, CG = Congested Traffic, CGFF = Congested and Free-Flowing Traffic, CVIF = Caltrans Vehicle Inspection Facility
E = Erosion, FF = Free-Flowing Traffic, H = Highway, M = Maintenance, P = Parking, R = Rest Area, TP = Toll Plaza, W = Watershed

Table B-2. California Toxics Rule and Ocean Plan Water Quality Objectives for Constituents in Caltrans Monitoring Projects.

		California Toxics Rule (ug/L)						*California Ocean Plan (ug/L)*					
		Aquatic Life: Freshwater		**Aquatic Life: Saltwater**		**Human Health**		**Marine Aquatic Life**			**Human Health**		
Constituent	***Fraction***	Acute	Chronic	Acute	Chronic	Water & Organism	Organism	6-month Median	Daily Max	Instant. Max	30-day Ave	**Narrative**	***Notes***
CONVENTIONALS													
pH												No change >0.2	
DIOXINS & FURANS													
TCDD equivalents											3.9E-09		D1
HYDROCARBONS													
Oil & Grease												Not visible	
METALS													
Ag	Diss	3.45		1.90									A
Ag	Total	4.06		2.24				0.7	2.8	7			A
As	Diss	340	150	69	36								
As	Total	340	150	69	36			8	32	80			
Be	Total										0.033		
Cd	Diss	4.26	2.24	42.0	9.30								A
Cd	Total	4.52	2.46	42.3	9.36			1	4	10			A
Cr (III)	Diss	549	178										A
Cr (III)	Total	1737	207								190000		A
Cr (VI)	Diss	16.0	11.0	1100	50.0								
Cr (VI)	Total	16.3	11.4	1108	50.4			2	8	20			
Cu	Diss	13.4	8.96	4.80	3.10								A
Cu	Total	14.0	9.33	5.78	3.73	1300		3	12	30			A
Hg	Diss												
Hg	Total					0.05	0.051	0.04	0.16	0.4			
Ni	Diss	468	52.0	74.0	8.20								A
Ni	Total	469	52.2	74.7	8.28	610	4600	5	20	50			A
Pb	Diss	64.6	2.52	210	8.1								A
Pb	Total	81.6	3.18	221	8.5			2	8	20			A
Sb	Diss												
Sb	Total					14.0	4300				1200		
Se	Diss			290	71.0								
Se	Total		5.0	291	71.1			15	60	150			B
Tl	Diss												
Tl	Total					1.70	6.30				2		
Zn	Diss	117	118	90.0	81.0								A
Zn	Total	120	120	95.1	85.6			20	80	200			A

Table B-2. California Toxics Rule and Ocean Plan Water Quality Objectives for Constituents in Caltrans Monitoring Projects (continued).

		California Toxics Rule (ug/L)						*California Ocean Plan (ug/L)*					
		Aquatic Life: Freshwater		**Aquatic Life: Saltwater**		**Human Health**		**Marine Aquatic Life**			**Human Health**		
Constituent	***Fraction***	Acute	Chronic	Acute	Chronic	Water & Organism	Organism	6-month Median	Daily Max	Instant. Max	30-day Ave	**Narrative**	***Notes***
MICROBIOLOGICALS													
Fecal Coliform	(per 100mL)							400*			200**	* 10% within 60 days ** Geometric mean	
Total Coliform	(per 100mL)								10000*		1000, 70, 230**	* 48 hour contact ** Max, median, 10%	
MINERALS													
Chlorine Residual								2	8	60			C
MISCELLANEOUS CONSTITUENTS													
Cyanide		22	5.2	1.0	1.0	700	220000	1	4	10			
Tributyltin											0.0014		
NUTRIENTS													
NH3-N	Total							600	2400	6000			
PCBS													
PCBs (total)			0.014		0.03	0.00017	0.00017				0.000019		D2
PESTICIDES													
4,4'-DDD						0.00083	0.00084						
4,4'-DDE						0.00059	0.00059						
4,4'-DDT		1.10	0.001	0.13	0.001	0.00059	0.00059						
Aldrin		3.0		1.3		0.00013	0.00014				0.000022		
alpha-BHC						0.0039	0.013						
alpha-Endosulfan		0.22	0.056	0.034	0.0087	110	240						
beta-BHC						0.014	0.046						
beta-Endosulfan		0.22	0.056	0.034	0.0087	110	240						
Chlordane		2.40	0.0043	0.09	0.004	0.00057	0.00059				0.000023		D3
DDT											0.00017		D4
Dieldrin		0.24	0.056	0.71	0.0019	0.00014	0.00014				0.00004		
Endosulfan								0.009	0.018	0.027			D5
Endosulfan Sulfate						110	240						
Endrin		0.086	0.036	0.037	0.0023	0.76	0.81	0.002	0.004	0.006			
Endrin Aldehyde						0.76	0.81						
gamma-BHC		0.95		0.16		0.019	0.063						
HCH								0.004	0.008	0.012			D6
Heptachlor		0.52	0.0038	0.053	0.0036	0.00021	0.00021				0.00005		
Heptachlor Epoxide		0.52	0.0038	0.053	0.0036	0.0001	0.00011				0.00002		
Toxaphene		0.73	0.0002	0.21	0.0002	0.00073	0.00075				0.00021		

Table B-2. California Toxics Rule and Ocean Plan Water Quality Objectives for Constituents in Caltrans Monitoring Projects (continued).

		California Toxics Rule (ug/L)						*California Ocean Plan (ug/L)*					
		Aquatic Life: Freshwater		**Aquatic Life: Saltwater**		**Human Health**		**Marine Aquatic Life**			**Human Health**		
Constituent	***Fraction***	Acute	Chronic	Acute	Chronic	Water & Organism	Organism	6-month Median	Daily Max	Instant. Max	30-day Ave	**Narrative**	***Notes***
SEMI-VOLATILE ORGANIC COMPOUNDS													
1,2-Diphenylhydrazine						0.04	0.54				0.16		
2,4,6-Trichlorophenol						2.1	6.5				0.29		
2,4-Dichlorophenol						93	790						
2,4-Dimethylphenol						540	2300						
2,4-Dinitrophenol						70	14000				4		
2,4-Dinitrotoluene						0.11	9.1				2.6		
2-Chloronaphthalene						1700	4300						
2-Chlorophenol						120	400						
2-Methyl-4,6-Dinitrophenol						13.4	765				220		
3,3'-Dichlorobenzidine						0.04	0.077				0.0081		
Acenaphthene						1200	2700						
Anthracene						9600	110000						
Benzidine						0.00012	0.00054				0.000069		
Benzo(a)Anthracene						0.0044	0.049						
Benzo(a)Pyrene						0.0044	0.049						
Benzo(b)Fluoranthene						0.0044	0.049						
Benzo(k)Fluoranthene						0.0044	0.049						
Bis(2-chloroethoxy)Methane											4.4		
Bis(2-chloroethyl)Ether						0.031	1.4				0.045		
Bis(2-chloroisopropyl)Ether						1400	170000				1200		
Bis(2-Ethylhexyl)Phthalate						1.8	5.9				3.5		
Butylbenzyl Phthalate						3000	5200						
Chrysene						0.0044	0.049						
Dibenzo(a,h)Anthracene						0.0044	0.049						
Diethyl Phthalate						23000	120000				33000		
Dimethyl Phthalate						313000	2900000				820000		
Di-n-Butyl Phthalate						2700	12000				3500		
Fluoranthene						300	370				15		
Fluorene						1300	14000						
Hexachlorobenzene						0.00075	0.00077				0.00021		
Hexachlorobutadiene						0.44	50				14		
Hexachlorocyclopentadiene						240	17000				58		
Hexachloroethane						1.9	8.9				2.5		
Indeno(1,2,3-c,d)Pyrene						0.0044	0.049						
Isophorone						8.4	600				730		
Nitrobenzene						17	1900				4.9		

Table B-2. California Toxics Rule and Ocean Plan Water Quality Objectives for Constituents in Caltrans Monitoring Projects (continued).

		California Toxics Rule (ug/L)						*California Ocean Plan (ug/L)*					
		Aquatic Life: Freshwater		**Aquatic Life: Saltwater**		**Human Health**		**Marine Aquatic Life**			**Human Health**		
Constituent	***Fraction***	Acute	Chronic	Acute	Chronic	Water & Organism	Organism	6-month Median	Daily Max	Instant. Max	30-day Ave	**Narrative**	***Notes***
SEMI-VOLATILE ORGANIC COMPOUNDS (continued)													
N-Nitrosodimethylamine						0.00069	8.1				7.3		
N-Nitrosodi-n-Propylamine						0.005	1.4				0.38		
N-Nitrosodiphenylamine						5	16				2.5		
PAHs											0.0088		D7
Pentachlorophenol		19.5	15.0	13	7.9	0.28	8.2						
Phenol						21000	4600000						
Phenolics								30	120	300		Non-chlorinated	
Phenolics, chlorinated								1	4	10			
Pyrene						960	11000						
VOLATILE ORGANIC COMPOUNDS													
1,1,1-Trichloroethane											540000		
1,1,2,2-Tetrachloroethane						0.17	11				2.3		
1,1,2-Trichloroethane						0.6	42				9.4		
1,1-Dichloroethylene						0.057	3.2				0.9		
1,2-Dichlorobenzene						2700	17000						
1,2-Dichloroethane						0.38	99				28		
1,2-Dichloropropane						0.52	39						
1,3-Dichlorobenzene						400	2600						
1,4-Dichlorobenzene						400	2600				18		
Acrolein						320	780				220		
Acrylonitrile						0.059	0.66				0.1		
Benzene						1.2	71				5.9		
Bromoform						4.3	360						
Carbon Tetrachloride						0.25	4.4				0.9		
Chlorobenzene						680	21000				570		
Chlorodibromomethane						0.401	34				8.6		
Chloroform											130		
cis-1,3-Dichloropropene											8.9		
Dichlorobenzene											5100		D8
Dichlorobromomethane						0.56	46				6.2		
Ethylbenzene						3100	29000				4100		
Halomethanes											130		D9
Methyl Bromide						48	4000						
Methylene Chloride						4.7	1600				450		
Tetrachloroethylene (PCE)						0.8	8.85				2		
Toluene						6800	200000				85000		

Table B-2. California Toxics Rule and Ocean Plan Water Quality Objectives for Constituents in Caltrans Monitoring Projects (continued).

		California Toxics Rule (ug/L)						*California Ocean Plan (ug/L)*					
		Aquatic Life: Freshwater		**Aquatic Life: Saltwater**		**Human Health**		**Marine Aquatic Life**			**Human Health**		
Constituent	***Fraction***	Acute	Chronic	Acute	Chronic	Water & Organism	Organism	6-month Median	Daily Max	Instant. Max	30-day Ave	**Narrative**	***Notes***
VOLATILE ORGANIC COMPOUNDS (continued)													
trans-1,3-Dichloropropene											8.9		
Trichloroethylene (TCE)											27		
Vinyl chloride						2	525				36		

NOTES:

A. CTR objectives are hardness dependent. The objectives shown were calculated based on a hardness level of 100 mg/L CaCO3. See the California Toxics Rule (CTR) for equations used to calculate objectives based on receiving water hardness.

B. The CTR aquatic life, freshwater, acute objective is 20 ug/L for certain waters (see CTR footnotes).

C. Chlorine residual objectives for intermittent discharges not exceeding 2 hours are calculated using Log y = -0.43(log x) + 1.8, where Y = objective (ug/L); x = duration (minutes).

D1. The Ocean Plan defines TCDD equivalents as the sum of 2,3,7,8-CDDs and 2,3,7,8-CDFs multiplied by their respective toxicity factors, as shown in the Ocean Plan.

D2. The Ocean Plan defines PCBs (total) as the sum of 1016, 1221, 1232, 1242, 1248, 1254, 1260.

D3. The Ocean Plan defines Chlordane as the sum of alpha and gamma chlordane, chlordene, nonachlor, and oxychlordane.

D4. The Ocean Plan defines DDT as the sum of 4,4', 2,4-DDT, 4,4', 2,4'-DDE, 4,4', 2,4'-DDD.

D5. The Ocean Plan defines Endosulfan as the sum of alpha, beta, and endosulfan sulfate.

D6. The Ocean Plan defines HCH as the sum of alpha, beta, delta, gamma hexachlorocyclohexane.

D7. The Ocean Plan defines PAHs as the sum of acenaphthylene, anthracene, 1,2-benzanthracene, 3,4-benzofluoranthene, benzo(k)fluoranthene, 1,2-benzoperylene, benzo(a)pyrene, chrysene, dibenzo(ah)anthracene, fluorene, indeno(123-cd)pyrene, phenanthrene, pyrene.

D8. The Ocean Plan defines Dichlorobenzene as the sum of 1,2- and 1,3-dichlorobenzene.

D9. The Ocean Plan defines Halomethanes as the sum of bromoform, methyl bromide, methyl chloride.

APPENDIX C

Flow Proportional Sampling

APPENDIX C
FLOW-PROPORTIONAL SAMPLING

A flow-proportional composite is comprised of multiple water quality samples each representing an equal flow volume. A flow-proportional composite is typically collected by sampling the flow of interest (e.g., stormwater runoff) at predetermined runoff volume intervals, e.g. one sample aliquot is collected for every thousand cubic feet (kcf) of flow. The principal advantages of flow-proportional composites (over time-proportional composites or grab samples) are that flow-proportional composites are not biased by over- or under-sampling any part of the hydrograph, and they allow direct estimation of Event Mean Concentration (EMC) and Event Mass Load (EML), without making assumptions about the shape of the hydrograph or the relationship between pollutant concentrations and flow rates. By sampling more frequently at higher flow rates (and less frequently at low flow rates) a flow-proportional composite stormwater sample allows direct analysis of the composite sample to estimate the EMC (defined as the arithmetic average concentration of the pollutant in the total runoff volume).

Flow-proportional composites also provide for direct calculation of the EML (defined as the total pollutant mass for a particular storm event) for each analyte of interest from the measured EMC and the total runoff volume for the event.

Figures C-1 and C-2 demonstrate when flow proportional composite samples would be collected for stormwater runoff from typical urban areas (C-1) and runoff from Caltrans facilities (C-2). In these graphs, each composite sample aliquot represents an equal flow volume, corresponding to an equal area under the curve.

The differences between the two hydrographs can be attributed to the unique characteristics of Caltrans watersheds. For example, Caltrans watersheds are relatively small (the largest currently monitored is approximately 30 acres) compared to typical urban watersheds examined in stormwater monitoring programs, which may be hundreds or thousands of acres. In addition, Caltrans watersheds are largely impervious, which results in increased runoff (i.e., a high runoff coefficient). These factors explain the quick response of runoff to rainfall, as demonstrated by the steep rise and fall of the hydrograph (Figure C-2).

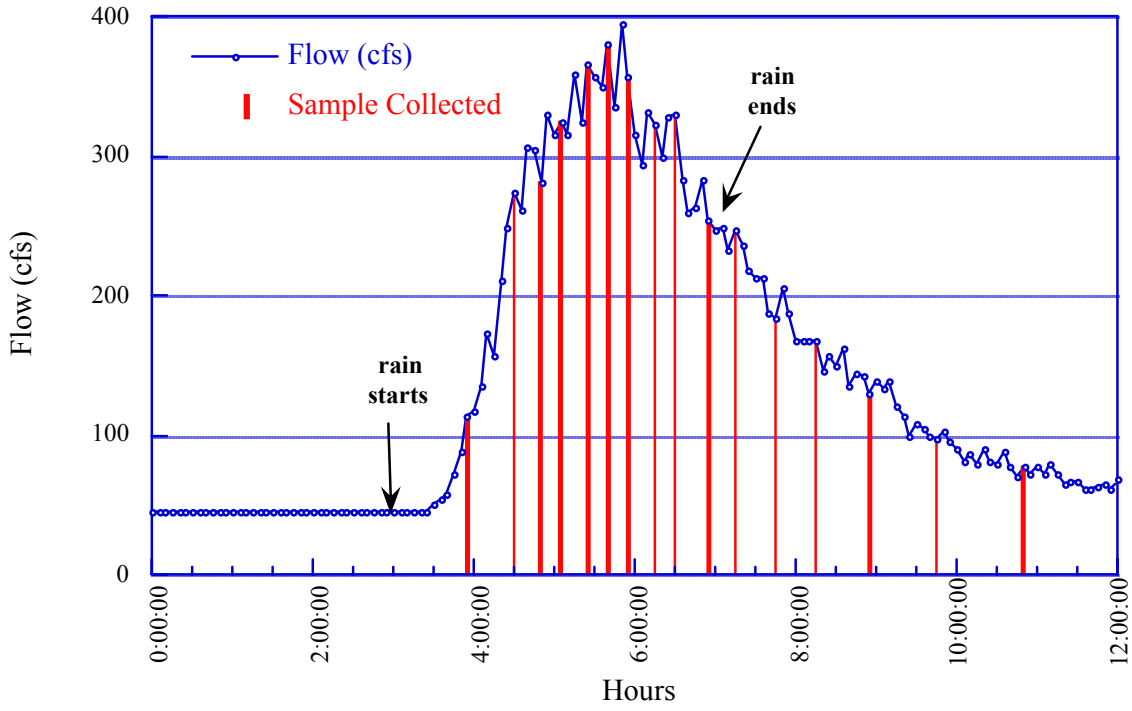

Figure C-1. Flow Proportional Sampling: Typical Urban Runoff Hydrograph

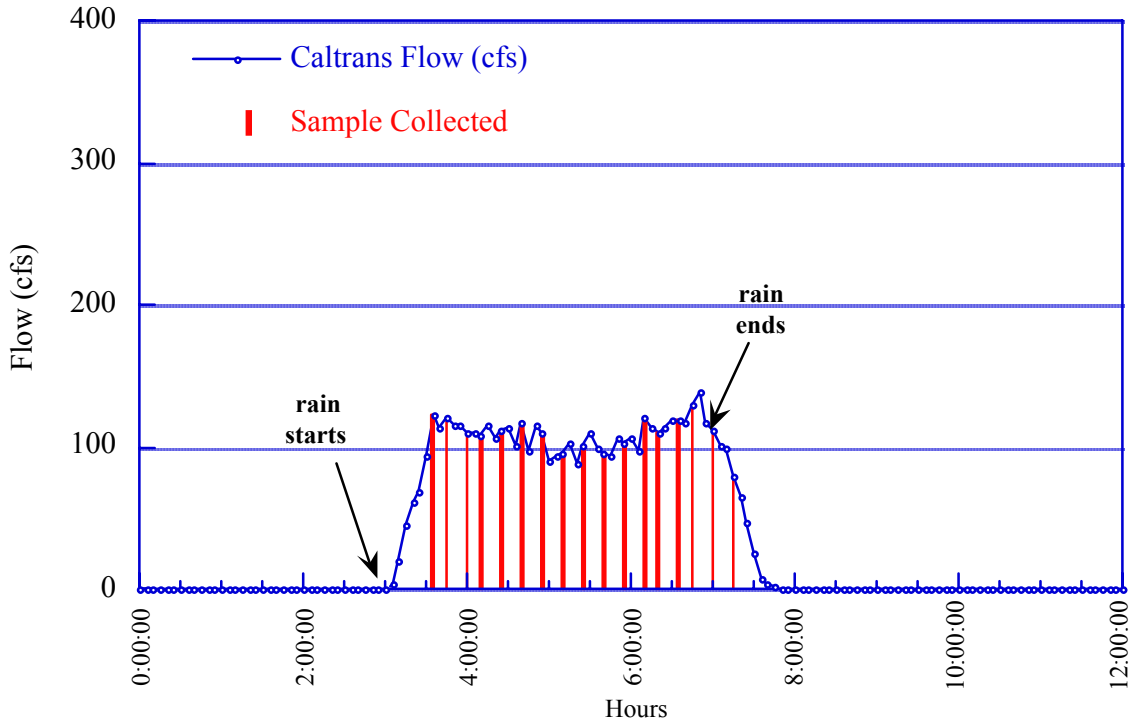

Figure C-2. Flow Proportional Sampling: Typical Caltrans Hydrograph

APPENDIX D

Health and Safety Plan Preparation

APPENDIX D
HEALTH AND SAFETY PLAN PREPARATION

This appendix includes specific information on the many components that should be included in a project health and safety plan (HSP). The information provided is presented as guidance and should be superseded by any established Caltrans standard operating procedures.

The following items should be discussed in the HSP:

- **Assignment of a Health and Safety Officer**
- **Field Activities**
- **Potential Hazards**
- **Health and Safety Precautions**
- **Health and Safety Training and Documentation**
- **Emergency Response/Contingency Plan**

➢ ASSIGN A HEALTH AND SAFETY OFFICER

A project health and safety officer should be assigned to oversee all health and safety activities. The responsibilities of the health and safety officer should include the following:

- Assure that each monitoring team member is familiar with the requirements of the HSP and that all personnel have received the necessary training.
- Implement the HSP, special safety considerations, and the emergency response/contingency plan.
- Alert appropriate emergency services before starting work and provide a copy of the emergency response/contingency plan to the respective emergency services.
- Record all significant health and safety activities and incidents.
- Suspend work due to health or safety related concerns.

All health and safety activities that differ from those stated in the final HSP must be approved by the designated health and safety officer.

➢ DESCRIBE FIELD ACTIVITIES

Carefully review the stormwater monitoring program and list all of the field activities that will be involved. A typical stormwater monitoring program may include accessing and occupying monitoring sites in difficult areas, lifting heavy or bulky equipment and other items, and handling stormwater samples, often under challenging conditions. The following describes some specific activities associated with stormwater monitoring.

Equipment installation and routine maintenance

Flow meters, water samplers and ancillary equipment may need to be installed, depending on the objectives and scope of the monitoring program. Installation usually requires entry into confined spaces and the use of power tools. The flow meter and automatic water sampler are suspended within the maintenance chamber or in an equipment shelter. Sampler intakes and flow meter sensors are secured to the stormwater conduit using a mounting strap. Sample tubing and sensor cables are secured and routed to the water sampler and flow meter. Routine maintenance consists of visual inspections of sampler intakes, flow meter sensors, mounting hardware, and equipment desiccants. Equipment calibrations may also be performed during maintenance visits.

Travel to and from sites

Field crews will be required to drive to and from each monitoring site, often in stormy conditions and sometimes at night.

Establish work zone and traffic controls

Traffic may be of concern at most Caltrans sampling sites. Therefore, Caltrans field crews will need to establish safe work zones and provide traffic control. All work zones and traffic control systems must provide for the safety of both field crews and general public (and must comply with applicable Caltrans regulations).

Opening and closing maintenance hole covers

Field crews will need to remove and replace maintenance hole covers. Maintenance hole lids should be removed and replaced using a specially designed maintenance hole hook. Maintenance hole covers should only be removed after the atmosphere inside the maintenance hole has been checked.

Flow meter and automatic water sampler setup

Both the flow meter and automatic water sampler will need to be programmed and started before each storm. Usually, the sampler is made operational from a key pad located on the sampler. The flow meter is made operational by using a keypad, laptop computer, or telemetry. If the key pad is used, confined space entry may be required since the meter is often located in a maintenance chamber.

Remove and replace automatic water sampler

Automatic water samplers located in maintenance chambers will need to be removed and replaced to service the sample bottles (i.e., install, check, remove). A cable harness can be rigged as the lifting handle. Full samplers can weigh 60 to 70 pounds.

Manually collect grab samples

Some projects may entail grab sampling using manual methods. In some cases, grab sampling can be accomplished by immersing the sample container into the channel. In other cases, a bailer or a beaker attached to a lanyard, pole, or other dipping apparatus may be required. In such cases, the sampler is lowered into the flow stream to collect the sample, which is then transferred into sample bottles.

➢ IDENTIFY POTENTIAL HAZARDS

Before workers can be adequately protected, the activities must be analyzed, and the anticipated hazards to their health and safety must be identified. The following summarizes the general classes of hazards expected to be present during stormwater sampling. The summary provided here is not intended to include every type of hazard that could be encountered; rather, it is intended to serve as a starting point for a site-specific analysis for a given project.

Confined Spaces

Storm sewers are classified as "confined spaces" under OSHA regulations. Regulations for entry into confined spaces are contained in 29 CFR 1910.146 and California Code of Regulation (CCR)-Title 8,-Article 108, confined spaces. The regulations require that no person shall enter a confined space without proper training and equipment. The risks associated with confined spaces include dangerous atmospheres, engulfment, falls, falling objects, and bodily harm due to explosion.

Physical Hazards

Physical hazards may include vehicle traffic, open maintenance holes and maintenance hole lids, and open water. Basic information is provided below regarding each of these hazards, however, specific Caltrans standard operating procedures should be used in the final HSP.

Vehicle traffic

Traffic hazards may be a primary concern at most Caltrans sampling sites. These hazards are greatest during times of reduced visibility, such as during storm events and at night. The primary threats associated with working in or alongside roadways are workers being struck by passing vehicles or being involved in a vehicular collision. The risk associated with these threats is severe bodily injury or death.

Open Maintenance Hole and Maintenance Hole Lids

Storm sewer sampling sites are often located below grade, such that maintenance holes must be opened during water sample collection and equipment maintenance activities. Opening maintenance holes requires the removal of heavy steel lids. Improper maintenance hole lid removal techniques can result in back injuries and/or crushed toes or feet. Specially designed maintenance hole hooks along with proper lifting techniques provide the easiest and safest way for removing maintenance hole lids.

Open maintenance holes pose a threat to workers and general public. Limited visibility, inattention, poor site control, slips, and/or trips could result in someone falling into an open maintenance hole. The risks of such a fall include minor to fatal bodily injury.

Open Water Hazards

High flows associated with storm events present a threat to workers. Slippery conditions, stream side vegetation, and unstable stream banks could cause a worker to fall into a stream. The risks of such a fall include hypothermia, bodily injury, and drowning.

Biological Hazards

Rodents and pathogenic microorganisms (including viruses), are potential biological hazards of concern. The primary threats associated with these hazards are injury from bites and/or the contraction of diseases.

Chemical Hazards

Although most stormwater sewers are not intended to contain hazardous materials, there is a potential for hazardous gaseous and/or liquid contaminants to be present as the result of industrial runoff, illicit sanitary sewer connections, and/or illegal dumping of wastes. The presence of chemicals and/or chemical vapors may result in (but not limited to) one or more of the following threats: toxic conditions, oxygen displacement, explosion, and/or fire. The risks associated with these threats include poisoning (acute and/or chronic), asphyxiation, and bodily injury.

➢ HEALTH AND SAFETY PRECAUTIONS

The following provides an overview of safety precautions and protective measures typically used to minimize the hazards described above. Again, this guidance is general in nature; it is not comprehensive and is not a substitute for a detailed, site-specific evaluation, or established safety regulations (Cal OSHA).

In addition to the items mentioned below, it should be noted that effective communication can enhance the health and safety of monitoring personnel. Cellular phones can be especially useful in this regard. If field personnel encounter unusual conditions, or are unclear as to how to deal with a given situation, they can contact their health and safety officer for guidance. Also, cellular phones can be used to summon help in the event of an accident or other emergency.

Confined Space Entry

Protective measures include use of atmospheric monitoring devices, portable ventilators, air purifying respirators, and entrant retrieval systems. Other precautions include prohibiting entry to some sites during storms and erecting pedestrian barriers. Caltrans confined space entry standard operating procedures should be adhered to if it is necessary for any personnel to enter a confined space for stormwater monitoring activities.

Physical Hazards

All field personnel should have the following personal protective equipment while working in the field:

- Hard hat
- Leather gloves (when working with maintenance hole covers, grates, and other related heavy objects, but not when handling samples or sampling equipment).
- Reflective traffic vest
- Steel-toed boots
- Eye protection
- Rain gear (during rainfall events)

This list represents the minimum protective equipment. The site-specific hazards evaluation for each project may determine that additional equipment is warranted for some sites/activities.

<u>Traffic Hazards</u>

Traffic should be controlled per existing Caltrans methods. All sampling personnel should be trained in proper traffic control including precautions and installation and use of appropriate controls. To the extent possible, try to schedule site visits for non-peak traffic periods.

Open Maintenance Hole and Maintenance Hole Lids

Maintenance hole safety precautions include both handling the heavy lids and controlling access to maintenance hole openings. Maintenance hole lids should only be moved using a hole hook; picks and crow bars are not acceptable substitutes. Maintenance hole hooks are designed not to slip while moving the lid. Safe lifting practices should be used when working with maintenance hole lids. Controlling access to maintenance hole openings can be done by erecting barriers and assigning a crew member to act as lookout and warn people away.

Open Water Hazards

The most effective precaution against open water hazards is to conduct work from a safe location such as bridge deck. If access to the waters edge is required, then a flotation vest and lifeline should be used.

Biological Hazards

To protect against bacterial and viral hazards, crews should avoid contact with stormwater samples. The use of powder-free nitrile gloves when handling samples is recommended. Crews should wash hands with soap and water before handling any food or drink. Any animals encountered during sampling should be avoided.

Chemical Hazards

Hazardous chemicals in storm sewers can be in either the liquid or vapor phase. Precautions against the liquid phase are similar to those described for biological hazards. Precautions against chemical vapors include use of air-purifying respirators and portable ventilators.

➢ HEALTH AND SAFETY TRAINING AND DOCUMENTATION

All persons who engage in stormwater sampling should receive some level of formal health and safety training. At a minimum, the project HSP should be presented and discussed in detail. This training should be recorded using an employee acknowledgment form. Regular safety meetings should also be held during the project to review and update safety procedures. The meeting content and persons in attendance should be documented.

Additional training in confined space entry may be necessary. Confined space entry requires specialized training as described in 29 CFR 1910.146 (or consult Caltrans existing standard operating procedures). The training should include how to identify confined spaces, atmosphere monitoring, lock-out and tag-out, retrieval systems, emergency response, and permit preparation. Any person entering a confined space must have documentation to support that they have received the required training.

Establish protocols to ensure that new additions to the monitoring team receive the proper health and safety training. Also, the training program should include periodic "refresher" courses.

➢ DEVELOP AN EMERGENCY RESPONSE/CONTINGENCY PLAN

An emergency response/contingency plan must be developed prior to any sampling activities. The plan should include instruction and procedures for medical emergencies, fires/explosions, hazardous material spills, and site evacuations. All emergency conditions require concise and timely actions conducted in a manner that minimizes the health and safety risks. All monitoring personnel should be familiar with the emergency response/contingency plan.

In most instances, the health and safety officer is responsible for assessing emergency situations and contacting the appropriate emergency services if necessary. If the health and safety officer is not available, emergency assistance should be contacted immediately. All personnel should be trained in basic first aid, be familiar with proper evacuation procedures, and have access to emergency numbers and routes to the nearest medical emergency facilities from each site. Emergency numbers should include at least the following: local police and fire department (911), closest hospital, county environmental health, and Hazmat team.

APPENDIX E

Sample Bottle and Equipment Cleaning Procedures

APPENDIX E
SAMPLE BOTTLE AND EQUIPMENT CLEANING PROCEDURES

Cleaning procedures should be established for all sample containers and equipment used for sample collection in the field and/or sample storage in the laboratory, and should be completed prior to sample collection. Teflon tubing, lids, and strainers, may all contact the sample during collection, therefore they must also be cleaned with the appropriate procedures. In addition, while performing these procedures personnel must use the correct equipment and safety gear.

The following examples outline cleaning procedures that may be used for composite bottles (carboys), metals analysis storage bottles, and teflon tubing, lids, and strainers. Appropriate cleaning solutions, safety precautions, and quality control are also discussed.

➢ EXAMPLE CLEANING PROCEDURES

Composite Bottles (carboys)

1. Rinse bottle with warm tap water three times as soon as possible after emptying sample.
2. Soak in a 2% detergent (e.g., Contrad®) solution for 48 hours; scrub with clean plastic brush.
3. Rinse three times with tap water.
4. Rinse five times with Milli-Q® or equivalent water (passed through two filters after deionized system), rotating the bottle to ensure contact with the entire inside surface.
5. Rinse three times with hexane, rotating the bottle to ensure contact with the entire inside surface (use 30 ml per rinse).
6. Rinse six times with Milli-Q water.
7. Rinse three times with 2N nitric acid (1 liter per bottle, per rinse) rotating the bottle to ensure contact with the entire inside surface.
8. Rinse six times with Milli-Q water.
9. Cap bottle with Teflon lined lid cleaned as specified below.

Metals Analysis Storage Bottles

1. Use only new, plastic 0.5 liter bottles.
2. Rinse five times with Milli-Q water, rotating the bottle to ensure contact with the entire inside surface.
3. Rinse three times with 2N nitric acid (20ml per bottle per rinse), rotating the bottle to ensure contact with the entire inside surface.
4. Rinse with Milli-Q water six times.
5. Store bottles filled with 1% metal-free nitric acid solution until ready to use.
6. Empty acid solution and rinse three times with Milli-Q water.

Teflon Tubing, Lids, and Strainers

1. Make up a 2% solution of disinfectant soap (e.g. Micro®) in warm tap water.
2. Rinse tubing three times with the 2% Micro Solution, wash lids and strainers with micro solution and plastic brush.
3. Rinse three times with tap water.
4. Rinse three times with Milli-Q water.
5. Rinse three times with a 2N nitric acid solution.
6. Soak 24 hours in a 2N nitric acid solution.
7. Rinse three times with Milli-Q water.
8. Seal the tubing on both ends with clean latex material
9. Individually double-bag tubing in new polyethylene bags properly labeled. Double-bag lids and strainers individually in zip-lock bags.

➢ CLEANING SOLUTIONS

2% Contrad = 200 ml concentrated Contrad (detergent) per full 10L bottle
2% HNO3 Acid = 80 ml concentrated HNO3 acid (16N) per gallon of Milli-Q water
2% Micro = 80 ml concentrated Micro (disinfectant) per gallon of Milli-Q water

➢ SAFETY PRECAUTIONS

All of the appropriate safety equipment must be worn by personnel involved in the cleaning of the bottles due to the corrosive nature of the chemicals being used to clean the bottles and tubing. This safety equipment must include protective gloves, lab coats, chemically resistant aprons, goggles with side shields and respirators. All material safety data sheets (MSDSs) must be read and signed-off by personnel.

➢ QUALITY CONTROL

Powder-free nitrile gloves must be worn while cleaning and handling bottles and equipment. Care must be taken at all times to avoid introduction of contamination from any source.

To account for any contamination introduced by sampling containers, blanks must be collected for composite bottles and laboratory bottles used for sample storage for metals analysis. A sampling container blank is prepared by filling a clean container with blank water and measuring the concentrations of selected constituents (typically metals and trace organics for composite bottles; metals analysis only for metals storage bottles). These blanks may be submitted "blind" to the laboratory by field personnel or prepared internally by the laboratory. Collection of sample container blanks is not required if certified pre-cleaned bottles are used. The manufacturer can provide certification forms that document the concentration to which the bottles are "contaminant-free"; these concentrations should be equivalent to or less than the program reporting limits. If the certification level is above the program reporting limits, 2% of the bottles in a "lot" or "batch" should be blanked at the program detection limits with a minimum frequency of one bottle per batch. A batch is a group of samples that are cleaned at the same time and in the same manner; or, if decontaminated bottles are sent directly from the manufacturer, the batch would be the lot designated by the manufacturer in their testing of the bottles.

APPENDIX F

Clean Sampling Techniques

APPENDIX F
CLEAN SAMPLING TECHNIQUES

The following text describes clean sampling techniques that should be used when ultra-low-level analytical detection limits are to be employed for analysis of metals or organic constituents.

The following topics are discussed below:

- **Clean Sample and Equipment Handling**
- **Composite Bottle Changing**
- **Bottle and Equipment Cleaning**

➢ CLEAN SAMPLE AND EQUIPMENT HANDLING

During all sampling operations, extreme care must be taken to minimize exposure of the sample and sample collection equipment to human, atmospheric, and other sources of contamination. This section provides clean sample and equipment handling procedures to be used when samples are collected for low-level analysis. Consult Section 10 for overall guidance on clean sampling techniques that should be employed for collection of all stormwater samples.

Clean sampling techniques typically require a two person sampling team. Upon arrival at the sampling site, one member of the sampling team is designated as "dirty hands"; the second member is designated as "clean hands". All operations involving contact with the sample bottle, sample bottle lid, sample suction tubing, and the transfer of the sample from the sample collection device (if the sample is not directly collected in the bottle) to the sample bottle are handled by "clean hands" wearing clean powder-free nitrile gloves. "Dirty hands" (also wearing clean powder-free nitrile gloves) is responsible for preparation of the sampler (except the sample container itself), operation of any machinery, and for all other activities that do not involve handling items that have direct contact with the sample. "Clean hands" will change into clean gloves as frequently as required to ensure that the gloved hands contacting the sample container, container lid, and laboratory cleaned sampling equipment have not contacted any source of potential contamination.

Although the duties of "clean hands" and "dirty hands" would appear to be a logical separation of responsibilities, in fact, the completion of the entire protocol may require a good deal of coordination and practice. For example, "dirty hands" must open the box or ice chest containing the sample bottle and unzip the outer bag; "clean hands" must reach into the outer bag, open the inner bag, remove the bottle, collect the sample, replace the bottle lid, put the bottle back into the inner bag, and zip the inner bag. "Dirty hands" must close the outer bag and place the double-bagged sample in an ice-filled ice chest.

It is recommended that a third sampling team member be available to direct the team, review the monitoring plan, and complete the necessary sample documentation (e.g. sample location, time, sample number, weather conditions, etc.). If a third sampling team member is not available, "dirty hands" must perform the sample documentation activities.

➢ COMPOSITE BOTTLE CHANGING

If an automated monitoring station is used for the collection of composite stormwater samples and a composite bottle change is required, composite bottle changing is conducted using the following steps:

1. The automated sampling equipment is placed in pause mode prior to the initiation of a composite bottle change. This action is accomplished in the field or by remote monitoring personnel if the monitoring station is equipped with telemetry.
2. Composite bottle changing requires two field crew members-"clean hands" and "dirty hands". Both team members wear clean, powder-free nitrile gloves. "Clean hands" only touches suction tubing and Teflon composite bottle lids. Keep extra gloves within easy reach.
3. Prior to putting on clean gloves, the clean empty sample bottle is placed near the automated sampling unit, and the sampler is opened.
4. Wearing clean powder-free nitrile gloves, "dirty hands" removes the lid clamps from both the full sample bottle and the clean sample bottle.
5. "Clean hands" removes the end of the pump tubing from the composite bottle and "dirty hands" places a clean ziplock bag over the end of the tubing securing it with a rubber band. The inside of the bag should never be touched by sampling personnel.
6. "Clean hands" switches the bottle lids, putting the solid lid on the full bottle and the perforated lid on the clean empty bottle.
7. "Dirty hands" installs the lid clamps on both bottles, removes the full bottle from the sampler, replacing it with the clean empty bottle.
8. "Clean hands" holds the tubing while "Dirty hands" removes the ziplock bag from the end of the pump tubing, being careful not to touch the tubing.
9. "Clean hands" inserts the tubing through the lid of the clean bottle.
10. The sampler is closed and sampling equipment is placed in sample mode. Remote operation personnel are notified as soon as the bottle change is complete.
11. The sampling team fills out the appropriate information on the label of the full sample bottle.
12. The full bottle is surrounded with fresh ice or frozen refreezable ice packets, and secured inside the vehicle for transport.

➢ BOTTLE AND EQUIPMENT CLEANING

When use of the preceding clean techniques is called for, additional effort should also be made in the area of bottle and equipment cleaning. In most cases this should involve, at a minimum, the procedures detailed in Appendix E. Consult also EPA Method 1669, *Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels*, and relevant individual 1600 series methods for further information.

APPENDIX G

Weather Tracking

APPENDIX G
WEATHER TRACKING

This appendix discusses California meteorology and available weather tracking services in the state (i.e., forecasting services used by other stormwater monitoring programs).

California weather is generally characterized by a wet season (late fall through early spring) and an extended dry season (late spring through early fall). However, annual average rainfall ranges from less than five inches in desert areas of southeastern California to over 40 inches in northern coastal areas. Valley and coastal areas receive virtually all of their precipitation as rainfall and rarely receive snow, while mountainous areas typically experience abundant snowfall, particularly at higher elevations.

The vast majority of storm systems approach California from the Pacific Ocean. Storm tracks tend to follow the jet stream, a high altitude, high speed wind current which moves generally from west to east around the globe. The most common storm track for weather approaching California begins with low pressure systems that originate in the Gulf of Alaska, and follow the polar jet as it bends southeasterly towards the California coast. These systems tend to be relatively cold and produce snowfall at relatively low elevations. Also common are storm systems that form in the Pacific Ocean to the west/southwest of California, and follow the subtropical jet stream as it runs northeasterly towards California. These storms tend to be warmer, with a higher snow line.

Weather information is provided by the National Weather Service (NWS), a federal agency, and private weather forecasting contract services. National Weather Service is a primary source of weather information for public and private sector forecasters. NWS collects and processes satellite imagery and other atmospheric data, and runs the major weather forecast models. Models are available for near term (1-2 days), medium range (3-5 days) and long range forecasting. Model reliability and specificity decline with extended time periods. The model output can be used to indicate potential candidate monitoring events up to one week in advance; however, at that time interval the model predictions are useful only as a rough indication of the likelihood of a precipitation event.

The forecasters at NWS, as well as private contractor forecasters and news media (television) forecasters, use the model outputs together with other meteorological data (satellite and radar imagery, water vapor/atmospheric pressure/temperature data, etc.) to make their predictions. The NWS makes its forecast predictions available to the public. The NWS forecasts are produced every twelve hours (at approximately 9:00 a.m. and p.m.), along with a written discussion of model output and weather observations. These discussions are meant for a professional meteorological audience, and are highly abbreviated and cryptic, but often provide insight into the basis for the published forecast.

Private weather forecast services can be found by looking in the yellow pages of major city telephone books. Most private forecast services will provide semi-weekly written forecasts, and 24-hour availability for telephone consultation. The following is a partial list of private California weather forecast services:

- Weather States Weather Service
- Weather Network
- Weather Watch

An example of a typical semi-weekly written forecast is presented as Figure G-1.

WEATHER NEWS
SACRAMENTO METROPOLITAN AREA
LARRY WALKER ASSOCIATES
ISSUED THURSDAY MARCH 6, 1997 10:00am

SYNOPTIC SITUATION (Today, tonight, and tomorrow): A weak upper-level trough is passing over Northern California this morning. The front associated with this trough moved over the northern end of the state overnight dropping some light rain up along the North Coast. It moved east of the state around dawn and has dissipated south of 40N (Chico). Another weak trough will brush the North State tonight/early Friday. It will develop tomorrow afternoon in its wake.

3-5 DAY FORECAST (Sat-Wed): Most of the forecast models continue to agree on building a moderately strong upper-level ridge of high pressure over the Eastern Pacific this weekend which should result in fair weather and warmer than normal temperatures through Monday. There is one rogue model solution that suggests a trough passage on Saturday which is hard to completely ignore since this morning's satellite imagery shows a fairly healthy surge of moisture streaming across the forecast on the ridging solution. Computer problems with the NWS back in D.C. have delayed the latest medium range forecast model output this morning. The last three runs have consistently shown an impressive Eastern Pacific trough developing around the middle of next week. It's a little too early to be really confident, but chances are a significant storm system will move across Northern and Central California around Wednesday/Thursday next week.

SACRAMENTO AREA
PRECIPITATION FORECAST:

	(WEST) DAVIS-SACRAMENTO	(EAST) CARMICHAEL-FOLSOM	POP	START TIME	STOP TIME
Today (9am-6pm)	None	None	0	--	--
Tonight (6pm-Midnight)	None	None	0	--	--
				--	--
Friday	None	None	0	*	*
Saturday	Tr - .10	Tr - .10	10	--	--
Sunday	None	None	0	--	--
Monday	None	None	0	PM	*
Tuesday	Tr - .35	Tr - .35	40	*	*
Wednesday	.25 - .75	.30 - .85	60		

Precipitation amount, in inches, for a 12 or 24 hour period beginning and ending at noon or midnight as defined above. This amount represents the most likely quantity of rain expected during the defined period.

POP - Probability of precipitation
* - Precipitation which is showery or sporadic in nature or that is too far in the future to determine with any certainty.

FORECASTER: Walsh

Figure G-1. Typical Semi-Weekly Written Weather Forecast

APPENDIX H

2003-2004 Caltrans Data Reporting Protocols

APPENDIX H

2003-2004 WATER QUALITY DATA REPORTING PROTOCOLS

The *2003-2004 Water Quality Data Reporting Protocols* can be found in the Data Reporting section of this manual.

SECTION 1.2

Caltrans Monitoring Protocols: Particle/Sediment Monitoring

CTSW-RT-02-018

CALTRANS MONITORING PROTOCOLS GUIDANCE MANUAL: PARTICLE/SEDIMENT MONITORING

AUGUST 2002

Prepared for:
CALIFORNIA DEPARTMENT OF TRANSPORTATION
1120 N STREET
SACRAMENTO, CA 95826

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Section 1
Introduction

This manual presents guidance for Caltrans management, staff, and contractors to use in the planning and implementation of monitoring studies that characterize the particles found in storm water runoff. The manual is designed and organized to provide step-by-step descriptions of the processes used to plan and implement successful particle monitoring studies specific to runoff from transportation-related facilities.

The main objective of this manual is to provide consistency in particle study methods among all Caltrans storm water investigations.

Consistency is essential for data comparability, and for ease of data entry in the Caltrans storm water database. In addition to consistency of particle study methods, it is essential that the particle samples are collected and analyzed according to methods and procedures that result in accurate and precise data. This manual therefore features detailed information on quality assurance and quality control procedures as they relate to particle sampling and analysis.

Particle characterization is considered a supplemental monitoring approach that can be used to support other water quality studies by providing further assessment of potential storm water impacts to aquatic systems. Particle monitoring can be performed to determine the range of grain sizes found in storm water runoff and the constituents that become attached to individual particles. The particles can be analyzed using standard laboratory methods.

This guidance manual is specifically prepared to address the particle studies undertaken by Caltrans to evaluate storm water runoff from transportation facilities. Methods for addressing receiving water sediments are beyond the scope of this manual and therefore not discussed in this document. Many of the components involved in planning and implementing particle studies are similar to those presented in the in Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition). Therefore, this manual is organized in the same manner, with minor variations, as the Storm Water Monitoring Protocols document, with two primary parts presented below.

Part I: Preparing the Study Plan

- Comprised of Sections 2 through 5, covering topics relevant to planning particle studies.
- Topics include developing purpose and objectives, site selection, testing type selection, selection of sample collection methods and equipment, and documentation.

Part II: Implementing the Study Plan

- Comprised of Sections 6 through 10, covering topics relevant to implementing a particle study plan.
- Topics include sample collection, quality assurance/quality control, laboratory sample preparation and analytical methods, quality assurance and quality control (QA/QC) data evaluation, and data reporting.
- Training, preparation, and logistics are additional components of implementing any storm water study. Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition) provides details concerning training, preparation, and logistics for storm water studies. These sections of the water quality document should be consulted for guidance when conducting Caltrans particle studies.

Section 2
Develop Purpose and Objectives

This section of the manual outlines the systematic decision-making process necessary to plan a Caltrans particle study that will achieve project-specific goals and objectives, including the development of appropriate data quality objectives (DQOs). The process includes the following seven steps that summarize the systematic planning process (U.S. EPA, 2000):

- Determine Project Goals and Objectives
- Identify Resources and Constraints
- Identify Data Characteristics and Tools
- Determine Key Study Parameters
- Specify Methods for Obtaining Data
- Develop Performance/Acceptance Criteria
- Optimize the Design for Obtaining the Data

Throughout this planning process is it essential to bear in mind that runoff from transportation facilities is generally episodic in nature, such as either derived from storm events or snowmelt. The study design must therefore account for the sporadic and transitory nature of the runoff events.

This seven-step process listed above is illustrated in Figure 2-1 and each step of the process is discussed in the following subsections.

2.1 Determine Project Goals and Objectives

The overall goal(s) of the study are used to determine the specific questions that the study will be designed to answer; from these questions, specific study objectives are developed, as discussed below.

The initial step in the development of a particle study plan is to determine the goal of the project based on the task order or problem statement presented by Caltrans. The overall goal of the study will in most cases have been defined previously in the Caltrans Storm Water Management Plan (SWMP) and other planning documents.

Once the goal of the study is defined, the project purpose can be stated so as to direct the project to provide data to fulfill the study goal. The goal and purpose of the study are strongly linked, and should be explicitly stated in the study plan. The purpose of the study is, generally speaking, to provide data in fulfillment of the study goals. Once the program goals and purpose are established, a set of specific study questions and objectives should be developed.

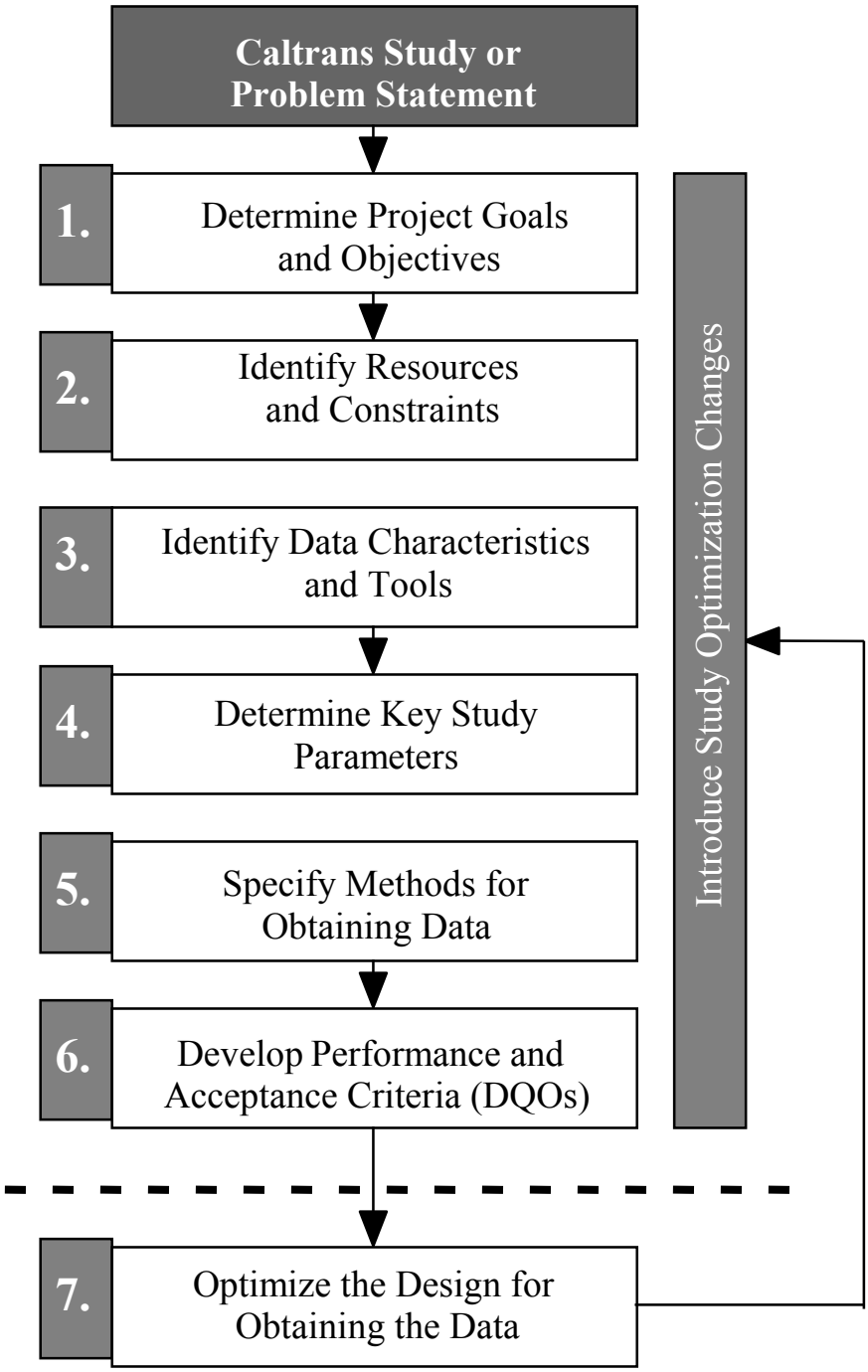


Figure 2-1. Systematic Planning Process Flow Chart

Caltrans particle studies will be designed typically to characterize the particles found in runoff in terms of grain sizes, weight of particles, and chemical content. This can be accomplished using a variety of approaches, depending on the nature of the specific study objectives. When designing specific project goals, applicable regulatory requirements must be considered in formulating the key question(s).

Typical questions that may be applied to Caltrans particle study projects include:

1. *What is the grain size distribution of particles found in runoff?* Figure 2-2 is a diagram of grain size (diameter in microns [µm]) for various classifications of solids expected in runoff.

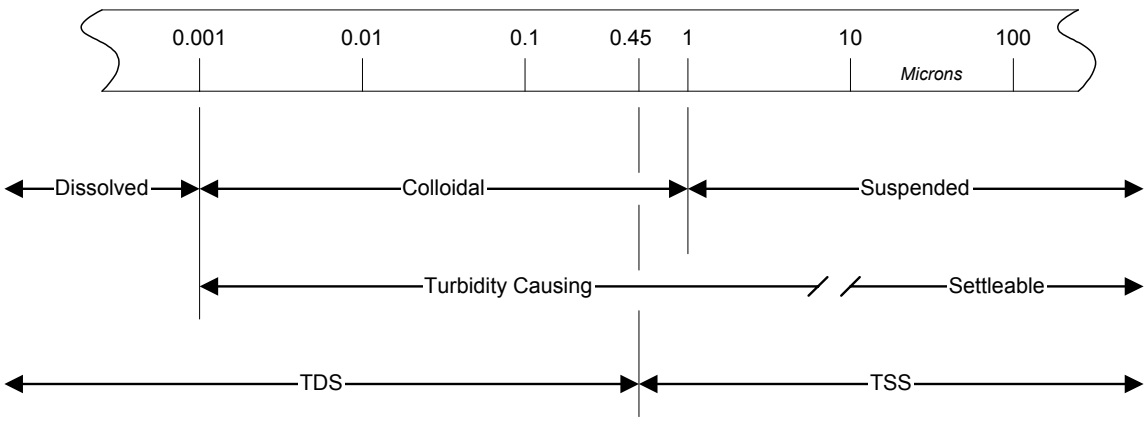


Figure 2-2. Grain Size Classification Scale

As shown, runoff will contain dissolved solids (<0.001 µm), colloidal solids (0.001 – 1 µm) and suspended solids (>1 µm). Colloidal solids and the smaller suspended solids (less than about 10 µm) typically are turbidity-causing while the larger suspended solids (greater than about 10 µm) are typically settleable. Settleable solids will settle out due to gravity over time, with the smaller particles requiring longer periods of time to settle. Colloids are microparticles that remain suspended in waters because their gravitational settling is less than 0.01 cm/sec (Stumm et. al 1981). Differentiation between the various categories of solids generally will vary depending on such parameters as particle density, chemical composition (organic versus inorganic), flow rate, and turbulence. The cut-off between turbidity-causing and settleable solids is especially sensitive to these parameters and will, therefore, vary depending on site conditions. Conversely, the cut-off between total dissolved solids (TDS) and total suspended solids (TSS) is normally defined at 0.45 µm by standard analytical methods. The 0.45 µm filtrate (measuring TDS) will contain turbidity causing colloids in addition to dissolved solids, while the particles retained on the 0.45 µm filter (measuring TSS) will consist primarily of particles in the suspended solids category (both turbidity-causing and settleable), with some larger turbidity-causing colloids.

2. *What is the chemical content, mineral makeup, and physical dimensions associated with particles?* These characteristics of the particles affect their mobility and bioavailability to aquatic organisms. For example, the oxidation/reduction status influences the retention or release of metals; the organic matter content affects the affinity of metals and nonpolar organic contaminants to the sediment; and the size and texture of the particles affects which contaminants are more readily adsorbed to the sediment particles.

   In addition, several particular constituents are found in highway runoff due to exposure to traffic. Typical constituents found in highway runoff and their sources are summarized in Table 2-1.

3. *Are specific chemicals and concentrations associated with certain grain sizes?* If certain grain sizes are found to contain contaminates or have higher levels of contaminates, BMPs should be designed or applied that focus on removing the particles associated with these grain sizes.

4. *What are the particle loads found in runoff?* Loads can be defined in terms of particle numbers and mass. The number of particles can be just as important as mass. Turbidity-causing particles may have a very high number load but represent a relatively low mass load. Removing the majority of the particle mass load may not remove the majority of the turbidity-causing particles.

Other potential objectives of Caltrans particle studies may be related to BMP effectiveness, land use types, and seasonal and/or other temporal trends. Specifically the following additional questions could be incorporated into particle studies:

1. *Are there differences in the particles in runoff from different locations or land uses?* Because runoff may come into contact with different materials, studies may be needed to quantify related differences in grain size and chemical content.

2. *Does BMP implementation change the grain size distribution or chemical load?* Particle evaluation can be an important tool for evaluating BMP performance, as particle data can be used to determine the effectiveness of a BMP at actually removing particles in the runoff, along with the associated pollutants. Knowledge of grain size distribution and the chemical content of each grain size category can also aid in effective selection of storm water BMPs, either through implementation of source controls for specific particles, or by the design and implementation of structural controls targeted at removal of the particles that represent the largest load.

Table 2-1
Sources of Pollutant Constituents

Constituent	Primary Sources
Particulates	Pavement wear, vehicles, atmosphere, maintenance, snow/ice abrasives, sediment disturbance, construction activity, agricultural activities
Nitrogen, Phosphorous	Atmosphere, roadside fertilizer use, sediments
Lead	Tire wear, lubricating oil and grease, bearing wear, atmospheric fallout
Zinc	Tire wear, motor oil, grease
Iron	Auto body rust, steel highway structures, engine parts
Copper	Metal plating, bearing wear, engine parts, brake lining wear, fungicides and insecticides use
Cadmium	Tire wear, insecticide application
Chromium	Metal plating, engine parts, brake lining wear
Nickel	Diesel fuel and gasoline, lubricating oil, metal plating, brake lining wear, asphalt paving
Manganese	Engine parts
Bromide	Exhaust
Cyanide	Anticake compound used to keep deicing salt granular
Sodium, Calcium	Deicing salts, grease
Chloride	Deicing salts
Sulphate	Roadway beds, fuel, deicing salts
Petroleum	Spills, leaks, blow-by motor lubricants, antifreeze, hydraulic fluids, asphalt surface leachate
PCBs, Pesticides	Spraying of highway right of ways, atmospheric deposition, PCB catalyst in synthetic tires
Pathogenic Bacteria	Soil litter, bird and animal droppings, trucks hauling livestock/stockyard waste
Rubber	Tire wear

Source: Kobringer, 1984.

3. *Are there seasonal (within a year) or temporal (between years) trends in particles?* Runoff quality is known to vary significantly from event to event (depending on the hydrological characteristics of the event), within and between seasons (depending upon factors related to the seasonal build-up and wash-off of pollutants, such as the antecedent dry period and cumulative rainfall to date), and from year to year (especially when comparing wet and dry years). It may be necessary to quantify the relative level and nature of particles in the runoff from these various temporal conditions.

Once study questions and objectives are known, specific project information needs are identified. The information needs must address any pertinent requirements (as specified in the NPDES permit or mandated through other state or federal regulations), and focus the study planning effort on providing answers to the key question(s) addressed by the project.

2.2 Identify Resources and Constraints

Specific resources available and constraints pertaining to implementing the particle study should then be identified. Data resources from previous studies, as well as other existing resources such as personnel, equipment, and services often support planned studies. Studies are typically constrained by time, available budget, physical

limitations of the study area, and practical weather constraints (e.g., number of storms in a year). These resources and constraints must be established during the planning process. Budget constraints are typically known from the beginning and generally affect the scope and detail of the study. The project may also be constrained by applicable regulatory or legal requirements.

2.3 Identify Data Characteristics and Tools

The study design should specify the expected characteristics of the data and the planned data analysis tools, so as to:

- Optimize collection of data within the financial and logistical/practical limitations of the proposed study
- Provide results that fulfill study objectives

For example, for a particle grain size study the quantity and quality of the data should be sufficient to develop a clear picture of the characteristics of the grain size distribution (i.e. grain size categories and percent based on either number or mass). This may equate to monitoring fewer sites (i.e., selecting representative sites) to develop detailed data, instead of monitoring a large number of sites to merely confirm that storm water runoff contains particles.

Essential data characteristics include the type of particle data to be collected (e.g., grain size, sediment amount or weight, chemical content), the variables affecting the data (e.g., antecedent conditions, rainfall intensity, site type and location), and the expected variability of the data (derived from previous studies when available).

Prior to the initiation of a particle study, a strategy should be developed for analysis of the data, directed to answering the specific study questions. The selected data analysis technique(s) may influence the type and quantities of data required to satisfy study objectives. The analysis methods applied to data collected for BMP evaluations or characterization studies typically involve straight-forward statistical operations; however, Caltrans data may be applied to multiple applications in the future (e.g., modeling applications, comparisons to other studies, and assessments of particles and sediments in receiving waters), and should be collected and presented in a manner that will allow the most versatile use of the data.

2.4 Determine Key Study Parameters

Key parameters of particle studies are determined using the information gathered in the previous steps of the systematic planning process. Key study parameters include site selection (see Section 3), number of monitored events and their temporal or spatial distribution, characteristics of target events, types of samples (composite, grab, etc.) and particle test methods (see Section 4). The better these characteristics are understood, the more efficiently the monitoring data can be collected.

The monitoring locations can be selected to optimize the physical monitoring of the environmental sample; this is discussed in more detail in Section 3. If possible, sites selected for particle studies should be monitoring stations in place for other programs, which will generate supporting water quality, litter, and toxicity data.

The planned numbers of sites and monitoring events are often constrained by fiscal factors; this involves not only the costs of sample collection, but also the costs of sample analysis. For this reason, the number and types of particle tests should be considered in the early stages of project planning (see Section 4), so the costs of the appropriate sample collection and analysis can be factored into the expected cost per monitoring event.

The types of storms or events to be monitored and optimal temporal distribution of monitoring events also should be considered during project planning. For example, if the project objectives include characterizing seasonal variation in particles, the monitoring events must be adequately distributed throughout the period(s) of interest. Besides seasonal distribution, a number of variables can be considered when selecting types of events to monitor. These variables could include storm size (rainfall amount), duration, and antecedent conditions (such as number of days since the previous rainfall). Event selection criteria should be developed to guide project managers in the appropriate selection of monitoring events during the monitoring season.

In addition to considering the types of storms to monitor, the timing of sample collection (as it relates to the event hydrograph) should also be considered. Possible approaches may include collection of a single grab sample during the initial or "first flush" portion of the event, collection of single grabs during discrete portions of the hydrograph (ascending, peak, and/or descending portions), collection of multiple grab samples at points throughout the event, or collection of an event-length composite sample.

2.5 Specify Methods for Obtaining Data

Once the key study parameters are known, appropriate sample collection and analysis methods are specified (see Sections 6, 7, and 9). This includes the types of samples collected and sample collection techniques (composite, grab, manual, passive, automatic, etc.), the equipment used to collect the samples, the particle evaluation methods, QA/QC procedures, and the specific procedures to be followed in accordance with the physical layout of the study site (e.g., which discharge flows best characterize the highway runoff and the practical considerations for collecting samples at that site). The sample collection methods must consider the laboratory analysis specifications for sample handling, containers, sample type, holding time, and preservation (see Sections 6 and 9).

2.6 Develop Data Quality Objectives

The central goal of any particle study is to provide scientifically defensible data in fulfillment of program objectives. This goal is best achieved through scientific design of the study and sound technical planning. Statistical methods may be used in the design of the study to determine the optimum number of sampling sites and sampling events (monitoring frequency) that will be needed to fulfill specific project objectives. Data quality objectives (DQOs) should be specified for the project to produce the data that will be useful in addressing study objectives, and to establish meaningful confidence levels for the monitoring data.

DQOs, as defined for this guidance document, specify the quality of data required to support the specified objectives of particle studies. DQOs generally are used to determine the level of quality considered to be acceptable in the data produced by the study; in large measure they are used to specify acceptable ranges of field sampling and laboratory performance.

A detailed discussion of the development of DQOs for Caltrans storm water monitoring projects is presented in the Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition). In general, the same systematic approach for determining DQOs for storm water monitoring projects applies to establishing DQOs for particle studies. Each project should include a thorough QA/QC data review and evaluation to assess project success in meeting accuracy and precision acceptance criteria (refer to Section 8 of this document).

Numerical DQOs should be established for constituent reporting limits, analytical precision, accuracy, completeness, and representativeness. These parameters are summarized below and discussed in detail in Sections 8 and 9 of this document. Project-specific DQOs should be specified in the sampling and analysis plan (SAP).

Reporting limits. Constituent reporting limits should be set low enough to reliably quantify constituents at meaningful levels. All efforts should be made to report constituent concentrations at levels greater than the reporting limit. The program-specific reporting limits identified in Sections 4 and 9 may be modified if site-specific data demonstrate that any change would improve the overall quality of collected data and still meet the DQOs.

Analytical precision and accuracy. Precision and accuracy of analytical results are often determined by historical laboratory performance; in some cases interlaboratory studies conducted by USEPA or others are used to set these limits.

Completeness. Completeness refers to the percentage of samples that are sampled and analyzed as planned, for which results are found to be valid following QA/QC data validation (see Section 8.5 in this document). A typical completeness level that can be expected of environmental analysis is 95%. Constituents that can occur as common laboratory contaminants may require a less restrictive DQO for completeness.

Representativeness. Representativeness for sediment samples in Section 6 and water samples is discussed in Section 7. Representativeness for sediment samples is based on surface variability, spatial coverage, and vertical profile. Representativeness for water samples is based on storm size, percent storm capture, and total number of composite sample aliquots.

2.7 Optimize the Design for Obtaining the Data

The systematic planning process, as applied to the Caltrans Statewide Stormwater Monitoring Program, is a synthesis of currently evolving USEPA guidance and the practical considerations of overall goals (Caltrans, 2000). The seven-step process described in this section is the starting point for structuring specific Caltrans particle studies. The seven-step process is iterative, with the final step providing for feedback to any of the previous six steps. The remaining sections of this manual carry out and build on these steps, from site selection to QA/QC data evaluation.

Ideally, the systematic planning process can be iterative for each project, as needed. It is possible to modify study parameters, with approval from the Caltrans task order manager, to optimize data collection to meet study objectives, based on newly collected data and field observations. This can sometimes be done during natural break points of the study (e.g., at the end of the wet season), when data are analyzed, and achievement of study objectives is assessed. In some cases, the collected information may indicate modifications are required to the study goals, the collection methods, the particle analyses, or the types and frequency of events sampled.

Section 3
Site Selection

Selection of sites for Caltrans particle studies should start with evaluation of monitoring stations that exist for other programs (e.g., existing Caltrans storm water monitoring locations). If possible these existing sites should be selected for particle studies to save time and resources and to provide supporting chemical, litter, or toxicity data. Some modifications and use of different sample collection methods may be required at existing runoff monitoring sites to accommodate the larger sample volumes needed for particle analyses (see Sections 6 and 7). Site selection will also depend on the program objectives and regulatory requirements. However, once these criteria have been used to establish the number and type(s) of monitoring sites, consideration of the following items will help select appropriate monitoring locations for particle studies:

- Representativeness
- Best Management Practices (BMP) Effectiveness
- Site Visit

This section focuses on use of pre-existing Caltrans runoff-monitoring sites for particle study sample collection. Storm water monitoring program site selection is discussed in detail in Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition), including information on the above items as well as personnel safety, site access, equipment security, flow measurement capability, electrical power, telephone, and run on from areas outside the Caltrans right-of-way (ROW). Site selection for receiving water studies is not included in this manual.

3.1 Representativeness

Types of runoff sampling sites specified for Caltrans monitoring may include highway sites (freeways, expressways and/or conventional highways as shown in Photo 3-1), maintenance yards, park-and-ride lots, or construction sites. It is important to select monitoring sites that are representative of typical Caltrans operations for these site types. The Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition) provides guidance on site characteristics to consider when selecting representative monitoring sites.

Photo 3-1. Documentation of potential highway monitoring site.

An additional consideration for particle studies may be to select sites that discharge directly into identifiable receiving water bodies. This would support future studies that may be conducted to investigate the potential receiving water impacts of Caltrans discharges.

3.2 BMP Effectiveness

Studies of BMP effectiveness involve different objectives than those for general storm water discharge monitoring. The goals of BMP monitoring programs are somewhat different as well. The Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition) provides detailed information concerning the selection of sites for BMP performance monitoring.

Site selection for BMP evaluation will depend upon the type of BMP (e.g., structural or non-structural). Structural BMPs typically have well-defined boundaries and may be relatively easy to monitor (Photo 3-2). When evaluating structural BMPs, monitoring locations should be located immediately upstream and downstream of the structure. This will allow for comparison between particles found in the storm water influent of the BMP and the storm water effluent of the BMP. Monitoring within the BMP may also be considered, such as at locations designed to trap sediments.

Photo 3-2. Documentation of potential detention pond BMP monitoring site.

Non-structural BMPs (e.g., street sweeping, catch basin cleaning, illicit discharge elimination) may be more difficult to monitor because they can be influenced by many factors that cannot be "controlled", and may not have clearly defined inlet and outlet flows. In such cases, it may be necessary to determine the particle characteristics in the runoff at the same sites before and after BMP implementation.

3.3 Site Visit

Each potential monitoring site should be visited to confirm the expected site characteristics and verify whether the site is suitable for the needs of the particle

study. When possible, a visit should be conducted during or after a storm, when the discharge flow conditions can be observed. A wet-weather visit can provide valuable information regarding logistical constraints that may not be readily apparent during dry weather. However, a dry-weather visit should also be conducted to observe any non-storm water flows. If any significant dry-weather flows are present this should be noted and considered during final site selection. Because some types of particle analyses require large sample volumes, the sample station equipment should be evaluated to ensure that adequate sample collection is possible. The site visit form used during the site visits conducted during the Statewide monitoring sites is shown in Figure 3-1. The form provides examples of elements to be considered when evaluating various sites during field visits.

FIGURE 3-1. SITE EVALUATION FORM

Date _____ Reviewer _____
District _____ County _____

City _____ Route/Post Mile _____

Address _____

Site Contact _____Telephone_____

TYPE OF SITE

☐ Highway ☐ Maintenance Station ☐ Park-and-Ride
☐ Rest Area ☐ Other

*Describe:*_____

_____

REPRESENTATIVENESS

Surrounding Land Use

☐ Transportation ☐ Agriculture ☐ Residential
☐ Commercial ☐ Industrial ☐ Open

Site Surroundings: ☐ Urban ☐ Rural

Describe: _____

Approximate Tributary Area (acres): _____

Upstream Site Topography (flat, steep, etc.): _____

Downstream Conveyance or Receiving Water Type: (e.g., storm drain, open channel, street, pond): _____

Is the drainage area 100 percent representative of site type? ☐ yes ☐ no
*Describe:*_____

Annual ADT _____ ☐ NA

Tidal influences ☐ yes ☐ no
Illegal dumping ☐ yes ☐ no

Ilicit connections ☐ yes ☐ no
High groundwater table ☐ yes ☐ no
Erosion ☐ yes ☐ no
Runoff from landscaped areas ☐ yes ☐ no
Is site representative of Caltrans Highways and/or Facilities? ☐ yes ☐ no

Explain for any questions answered "yes" _____

_____

Are there exposed materials that warrant additional analyses beyond the standard suite defined in the Caltrans Guidance Manual: ☐ yes ☐ no
If so, then list:

_____

_____

Other observations:

_____

_____

Overall Representativeness Rating (0 to 10): _____

PERSONNEL SAFETY

Personnel safety issues? ☐ yes ☐ no
(e.g., Proximity to traffic lanes, steep embankments traffic, toxic gases, explosives, slips/trips/falls, fast-moving water, confined spaces, etc.)
*Describe:*_____

Overall Personnel Safety Rating (0 to 10): _____

SITE ACCESS

Vehicular site access? ☐ yes ☐ no
*Describe:*_____
Continuous access during storms? ☐ yes ☐ no

*Describe:*_____

Site remote and/or travel to site subject to traffic delays? ☐ yes ☐ no

*Describe:*_____

Site subject to flooding? ☐ yes ☐ no

*Describe:*_____

Will monitoring activities interfere with Caltrans/motorists ☐ yes ☐ no

*Describe:*_____

Overall Site Access Rating (0 to 10): _____

EQUIPMENT SECURITY

Is the site subject to vandalism? ☐ yes ☐ no

*Describe:*_____

Is the site subject to other damage (e.g., errant drivers)? ☐ yes ☐ no

*Describe:*_____

Overall Equipment Security Rating (0 to 10): _____

FLOW MEASUREMENT CAPABILITY

Type of runoff from site: ☐ Curb and gutter ☐ Overland flow ☐ Other

*Describe:*_____

Potential sampling location (with access to flow):

☐ Storm drain inlet ☐ Ditch, swale ☐ Culvert ☐ Pipe

☐ Other (describe)_____

*Comments*_____

_____

Will the sampling point be unaffected by upstream BMPs? ☐ yes ☐ no

*Describe:*_____

Will the sampling location be unaffected by site activities? ☐ yes ☐ no

*Describe:*_____

Is grab sampling possible? ☐ yes ☐ no

*Describe:*_____

Is the sampling location subject to backwater conditions? ☐ yes ☐ no

*Describe:*_____

Will uniform flow be established? ☐ yes ☐ no

*Describe:*_____

Will the depth of flow be at least ¾ inches? ☐ yes ☐ no

*Describe:*_____

Is flow measurement feasible? ☐ yes ☐ no

*Describe:*_____

Will flow measurement be accurate? ☐ yes ☐ no

*Describe:*_____

Can the site be easily instrumented? ☐ yes ☐ no

*Describe:*_____

Can a primary flow measurement device be easily retrofitted? ☐ yes ☐ no

*Describe:*_____

What type of flow meter is most suitable?

☐ Bubbler ☐ Area/Velocity

☐ Ultrasonic ☐ Combination/Other_____

Overall Flow Measurement Capability Rating (0 to 10): _____

ELECTRICAL POWER AND TELEPHONE ACCESS

Electrical Power Available? ☐ yes ☐ no

_____

Telephone lines available? ☐ yes ☐ no

_____

Clear cellular phone reception at site? ☐ yes ☐ no

_____

Overall Electrical Power and Telephone Access Rating (0 to 10): _____

NON-CALTRANS SOURCES

Contributing off-site runoff	☐ yes	☐ no
Adjacent industrial sites	☐ yes	☐ no
Adjacent commercial farming	☐ yes	☐ no

Overall Non-Caltrans Sources Rating (0 to 10): _____

Note: Obtain site plans or draw a sketch and take photos.

Section 4
Particle/Sediment Constituent Selection

To select the specific constituents to be included in a given particle/sediment monitoring study, the following items should be considered:

- Project Objectives and Resources
- Regulatory Requirements
- Pollutant Sources in the Catchment Area
- Existing Monitoring Data
- Beneficial Uses/Impairments of the Receiving Water
- Typical Constituents to be Measured
- Testing Methods
- Phasing / Screening

Each of these considerations is discussed below, followed by a suite of possible analytical tests Caltrans may use for particle/sediment monitoring studies.

A summary schematic of the process for determining the types of tests to be conducted is shown in Figure 4-1. The procedure calls for examining the purpose and goals of the project, existing permit requirements, and any expected sources. Consideration of sampling and analysis costs (i.e., available project resources) is included as a final step in making this determination. This process allows selection of constituents that are the most appropriate for inclusion in the particle/sediment monitoring study.

4.1 Project Objectives and Resources

The types and number of particle tests selected for a given study will ultimately depend upon the objectives and available resources (e.g., personnel and funds). As discussed in Section 2, particle/sediment monitoring studies should be designed to answer the specific questions that were developed during the study design phase. Some of the objectives of a particle/sediment monitoring study include:

- Determine grain size distribution and mineral content of particles found in runoff
- Identify chemicals associated with particles and the concentrations
- Measure concentrations of specific chemicals associated with certain particle sizes
- Assess differences in the particles of runoff from different locations or land uses

- Evaluate BMP implementation effects on the grain size distribution or chemical load
- Identify seasonal (within a year) or temporal (between years) trends in particles

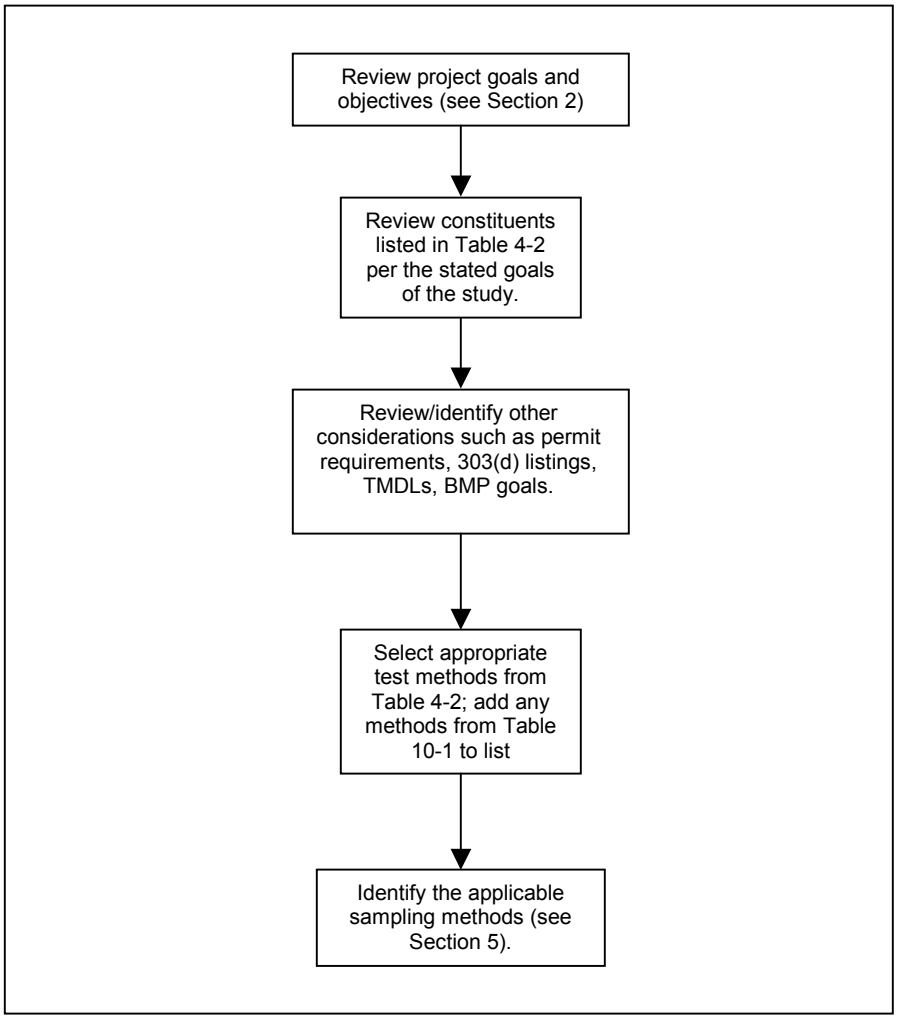


Figure 4-1
Schematic of Particle Test Method Selection Process

4.2 Regulatory Requirements

Currently, specific particle/sediment monitoring requirements are not outlined in the Caltrans Statewide Storm water NPDES permit. The permit does state that discharges shall not cause or contribute to violations of water quality objectives nor shall they cause certain conditions to occur which create a condition of nuisance or water quality impairment in receiving waters. As a permitted discharger, Caltrans may be obligated to fulfill related requirements under state or federal regulations, specifically the State Water Code or the Clean Water Act.

4.3 Pollutant Sources in the Catchment Area

Identifying potential constituent sources in the catchment area can aid in identifying the analytical methods to be employed. Caltrans projects may involve monitoring of runoff from highways, maintenance yards, park-and-ride lots, acceleration/deceleration zones, and construction sites. The potential constituent sources associated with each of these facilities may differ. A detailed description of the types of constituents expected from highway runoff, maintenance yards, rest areas, park-n-ride lots, and construction sites is provided in Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition). Sources of particulates and other highway-related pollutants are also summarized in Table 2-1.

4.4 Existing Monitoring Data

Table 4-1 provides a summary of the results of storm water runoff particle/sediment monitoring studies conducted by Caltrans. The existing data from these previous studies were used to form the basis for the list of Caltrans particle test types specified in Table 4-2.

Table 4-1
Related Caltrans Studies with Particle/Sediment Monitoring

Author (Year)	Study Title	Land Use / Sample Source	Tests
Caltrans (1998)	Solids Transport and Deposition Study (STDS)	Highways	Volume, Quality
Caltrans (2001)	Statewide Stormwater Runoff Characterization Study	All Caltrans facilities	TSS, TDS
Caltrans(2001)	Tahoe Basin Stormwater Runoff Characterization Study	Highways	Weight, TSS, TDS, Grain size, Quality

4.5 Beneficial Uses and Impairments of the Receiving Water

Information on receiving water quality can be used to indicate whether discharges from Caltrans facilities have the potential to adversely affect the receiving water body. For instance, constituents known to be associated with highway and transportation-related facility runoff can be compared with the constituents of concern identified in receiving waters, to determine if highway or transportation-related facility runoff have the potential to impact receiving water quality.

Caltrans guidance should be consulted regarding high priority receiving waters within each Caltrans District, to determine whether any constituents of concern should be added to the analytical constituents list for a particular project.

4.6 Typical Constituents to be Measured

A list of typical constituents to be considered for Caltrans particle/sediment monitoring projects is provided in Table 4-2. Data from previous studies conducted by Caltrans form the essential basis for this typical minimum suite of analytical constituents. In some cases it may be necessary to add additional constituents to this list, for example to address specific receiving water concerns.

4.6.1 Conventional Parameters

The conventional parameters that can be included in the analysis of water samples that are collected for particle/sediment studies include total dissolved solids (TDS), total suspended solids (TSS), suspended solids concentration (SSC), turbidity, and total organic carbon (TOC). Specific conductance and pH are also measured in water samples in either the field or laboratory. Sediment samples can be analyzed for TOC.

4.6.2 Nutrients

The list of nutrients that sediment samples can be analyzed for includes nitrite (as N), nitrate (as N), total Kjeldahl nitrogen (TKN), and total phosphorous.

4.6.3 Metals

The metal species and analytical methods available to define the contents and characteristics in sediments are listed below. The methods may be used individually or in concert to meet the DQOs of the project.

- Total – Results correspond to total concentrations in the sediment (mg/kg).
- TCLP – Extraction (or leaching) of the sediment sample using the Federal toxicity characteristic leaching procedure (TCLP) method, followed by ICP analysis of the leachate. The TCLP method (1311/6010B) is designed to evaluate the potential of the sediment to generate hazardous leachate (especially after disposal in a Municipal landfill). Results correspond to concentrations in the leachate (mg/L).
- STLC – STLC is the California equivalent of the TCLP (method CAM WET/6010B). In the STLC, a different extraction fluid is used. Results correspond to concentrations in the leachate (mg/L).

Table 4-2
Constituents and Recommended Reporting Limits

Analyte	Matrix	Reporting Limit (RL) [1]	Units
Conventional			
Total Suspended Solids (TSS)	Water	1	mg/L
Total Dissolved Solids (TDS)	Water	1	mg/L
Suspended Sediment Concentration (SSC)	Water	1	mg/L
Turbidity	Water	0.05	NTU
Total Organic Carbon (TOC)	Water / Sediment	50	mg/L or mg/kg
pH	Water	+/- 0.1	SU
Ec	Water	+/- 10	Semens
Nutrients			
Total Kjeldahl Nitrogen (TKN)	Sediment	20	mg/kg
Nitrate (NO3) as N	Sediment	1	mg/kg
Nitrite (NO2) as N	Sediment	1	mg/kg
Total Phosphorous (P)	Sediment	1	mg/kg
Metals (total)			
Arsenic (As)	Sediment	1	mg/kg
Cadmium (Cd)	Sediment	2	mg/kg
Chromium (Cr)	Sediment	5	mg/kg
Copper (Cu)	Sediment	2	mg/kg
Iron (Fe)	Sediment	5	mg/kg
Lead (Pb)	Sediment	5	mg/kg
Nickel (Ni)	Sediment	5	mg/kg
Zinc (Zn)	Sediment	2	mg/kg
Metals (TCLP)			
Arsenic (As)	Sediment	0.5	mg/L
Barium (Ba)	Sediment	5	mg/L
Cadmium (Cd)	Sediment	0.1	mg/L
Chromium (Cr)	Sediment	0.5	mg/L
Lead (Pb)	Sediment	0.5	mg/L
Mercury (Hg)	Sediment	0.01	mg/L
Selenium (Se)	Sediment	0.1	mg/L
Silver (Ag)	Sediment	0.5	mg/L
Metals (STLC)			
Antimony (Sb)	Sediment	1	mg/L
Arsenic (As)	Sediment	0.5	mg/L
Barium (Ba)	Sediment	5	mg/L
Beryllium (Be)	Sediment	0.1	mg/L
Cadmium (Cd)	Sediment	0.1	mg/L
Chromium (Cr)	Sediment	0.5	mg/L
Cobalt (Co)	Sediment	0.5	mg/L
Copper (Cu)	Sediment	0.1	mg/L
Lead (Pb)	Sediment	0.5	mg/L
Mercury (Hg)	Sediment	0.01	mg/L
Molybdenum (Mo)	Sediment	10	mg/L
Nickel (Ni)	Sediment	1	mg/L
Selenium (Se)	Sediment	0.1	mg/L
Thallium (Tl)	Sediment	0.5	mg/L
Vanadium (V)	Sediment	1	mg/L
Zinc (Zn)	Sediment	2	mg/L

Table 4-2
Constituents and Recommended Reporting Limits (continued)

Analyte	Matrix	Reporting Limit (RL) [1]	Units
Hydrocarbons			
TPH-G (gasoline)	Sediment	1	mg/kg
TPH-D (diesel)	Sediment	50	mg/kg
TPH-J (jet fuel)	Sediment	50	mg/kg
TPH-K (kerosene)	Sediment	50	mg/kg
TPH-S (stoddard solvent)	Sediment	50	mg/kg
VOCs			
Benzene	Sediment	5	mg/kg
Toluene	Sediment	5	mg/kg
Ethylbenzene	Sediment	5	mg/kg
Xylene	Sediment	15	mg/kg
Weight			
Dry	Sediment	0.1	g
Wet	Sediment	0.1	g
Grain Size Fraction			
Particle Size Distribution	Sediment	0.1	Fraction
Particle Counting	Water / Sediment	0.1	Fraction
Mineral Content			
Individual Mineral Species	Sediment	0.01	Fraction

[1] Note that the detection limit is usually less than the reporting limit

4.6.4 Organics

Particle/sediment samples can be analyzed for total petroleum hydrocarbon (TPH) compounds. TPH analyses for Caltrans monitoring projects will typically focus on gasoline and diesel hydrocarbons.

Additional organic constituents that may be analyzed include solvents. Although the majority of these constituents are volatile organic compounds (which readily evaporate and, therefore, not expected to be found in storm water runoff or the sediments), their inclusion in Caltrans storm water monitoring efforts may be important for characterization of runoff from maintenance yards.

4.6.5 Weight

The sediment samples or filtrate from water samples can be analyzed simply for weight of the collected sample. The weight can be expressed in terms of wet or dry, depending on whether the sample is dried prior to weighting.

4.6.6 Grain Size Fraction

The filtrate from water samples or sediment samples can be analyzed for grain size. Grain size is expressed in percent finer for a given grain size in terms of weight or particle number. Testing a whole range of grain sizes will provide the distribution, a useful method of characterizing particle content.

4.6.7 Mineral Content

There are hundreds of minerals types and infinite combinations found in runoff particles. Analytical methods are available that identify the mineral type and composition in terms of the fraction of the total particle.

4.7 Test Method Selection

Standard test methods have been established for the majority of the listed conventional constituents, nutrients, metals, organics, and grain size. The methods that meet the standard QA/QC requirements for Caltrans monitoring studies are presented in Section 9.

There are no standard methods for particle counting and mineral content. Alternative test methods for both particle counting and mineral content are discussed in Section 9.

4.8 Phasing/Screening

If a significant number of problem constituents are identified from the criteria discussed in this section (e.g., constituent sources, existing monitoring data, permit requirements, receiving water impacts) or if inclusion of certain constituents is questionable, a two-phased approach may be considered. During the first phase, conduct an initial screening by analyzing samples for a broad range of parameters of potential concern. Parameters not detected, or measured at levels well below concern, can be dropped from subsequent monitoring efforts (second phase).

Section 5
Sampling and Analysis Plan (SAP)

Proper documentation is required for all Caltrans particle studies. A SAP and Health and Safety Plan (HSP) should be prepared prior to initiation of any sampling activities.

This section provides general guidance for preparation of practical, useable SAPs for storm water particle monitoring programs. See Appendix D in Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition) for detailed information regarding individual components to be included in the HSP.

The following are sections that should be included in a SAP:

- Project Overview/Description
- Sampling Site(s)
- Constituents
- Data Quality Objectives (DQOs)
- Monitoring Preparation and Logistics
- Sample Collection, Preservation, and Delivery
- Quality Assurance/Quality Control
- Laboratory Sample Preparation and Analytical Methods
- Data Management and Reporting Procedures

Appendix:

- Health and Safety Plan (HSP)

Inclusion of these sections will allow for the development of a useable and practical SAP. The final product should be a single bound document that can be easily referenced during monitoring activities. The HSP can easily be included as an appendix to the SAP. Printing the SAP/HSP on waterproof paper will reduce the potential for water damage to the document during field use.

All Caltrans storm water monitoring documentation must be assigned a document identification number prior to document completion. The document identification number, assigned by the Storm water Management Program document distribution system manager, is used to track the document and develop document distribution lists. Two weeks prior to expected document deliverable date, the author must contact

the Caltrans storm water management program document distribution system manager to receive a document identification number and mailing labels.

Someone should prepare the SAP with a good understanding of field sampling procedures, laboratory testing methods, and data validation procedures. The analytical and soils laboratory(s) should provide input in order that the SAP (especially the QA/QC portion) is realistic, and consistent with the laboratory's operating procedures. Field personnel should also provide input regarding logistical details in order that the plan is practical and easy to use.

The SAP should include a thorough description of all activities required to implement the particle study. The plan should be organized to provide an overview of the project goals and organization, followed by a description of all monitoring activities in the chronological sequence in which they will typically occur. The plan should specify the quality assurance/quality control protocols that will be followed by field and laboratory personnel, and how the field and laboratory results will be managed and reported.

The contents of a typical storm water SAP are shown in Figure 5-1.

The following sub-sections further describe the contents of a typical storm water SAP that is applicable for particle studies.

5.1 Overview – Project Description, Organization, and Responsibilities

This section of the SAP should briefly describe:

- Description of why the particle study is being conducted
- Description of who is conducting the study
- General approach of particle monitoring activities

Roles and responsibilities of the key field and laboratory personnel who will be involved in the study (typical roles include project manager, sampling coordinator, sampling team leaders, field crew, project QA/QC officer, and laboratory QA/QC manager)

1.0 PROJECT OVERVIEW/DESCRIPTION
- 1.1 Description of why the project is being conducted
- 1.2 Description of who is conducting the project
- 1.3 General scope of monitoring activities
- 1.4 Project organization/roles and responsibilities

2.0 SAMPLING SITES
- 2.1 Site location (map) including Global Positioning System (GPS) coordinates
- 2.2 Written driving directions
- 2.3 Site access instructions (gates, locks, keys, combinations)
- 2.4 Notification procedures

3.0 PARTICLE TESTS
- Specifies the types of particle tests to be conducted to meet program objectives

4.0 DATA QUALITY OBJECTIVES (DQOs)
- 4.1 Analytical reporting limits
- 4.2 Analytical precision, accuracy, and completeness
- 4.3 Data Quality Evaluation Plan

5.0 FIELD EQUPMENT MAINTENANCE
- 5.1 Equipment calibration
- 5.2 Equipment maintenance
- 5.3 Equipment cleaning (bottles/lids/tubing)

6.0 MONITORING PREPARATION AND LOGISTICS
- 6.1 Weather tracking
- 6.2 Monitoring event selection criteria
- 6.3 Action levels
- 6.4 Communications/notification procedures
- 6.5 Sample bottle order
- 6.6 Sample bottle labeling
- 6.7 Field equipment preparation

7.0 SAMPLE COLLECTION, PRESERVATION, AND DELIVERY
- 7.1 Sample collection methods
- 7.2 Field measurement methods
- 7.3 Field equipment list
- 7.4 Sample containers, preservation, and handling
- 7.5 QA/QC sample collection methods
- 7.6 Sample labeling (site names/codes, etc.)
- 7.7 Composite sample splitting
- 7.8 Forms and procedures for documenting sample collection and field measurements
- 7.9 Laboratory communication procedures
- 7.10 Sample shipping/delivery, chain-of-custody

8.0 QUALITY ASSURANCE/QUALITY CONTROL
- Field procedures for QA/QC sample collection

9.0 LABORATORY SAMPLE PREPARATION AND ANALYTICAL METHODS
- 9.1 Laboratory sample preparation procedures
- 9.2 Particle Testing Methods (including testing methods, sample handling, and holding times)

10.0 DATA MANAGEMENT AND REPORTING PROCEDURES
- 10.1 Data validation
- 10.2 Electronic data transfer
- 10.3 Filing of electronic and hard copy data
- 10.4 Reports

APPENDIX
- A Health and Safety Plan

Figure 5-1
A Typical Stormwater Sampling and Analysis Plan Outline

5.2 Sampling Sites

This section should describe the sampling sites selected for the particle study and provide rationale for the inclusion of each site. Site selection for particle studies should focus on existing Caltrans storm water monitoring sites which were selected based upon representativeness of land uses in the area, achievable flow measurement, site access, personnel safety, equipment security, and availability of electrical power and telephone. See Section 3 for monitoring site selection guidance.

The following detailed information should be included for each monitoring site:

- Site location map
- GPS coordinates
- Written driving directions
- Site access instructions (locked gate keys or combinations)
- Reference to encroachment permits issued by the local District
- Notification procedures (if notification is required prior to site access)

5.3 Particle Tests

This section should specify the types of particle tests to be conducted to meet program objectives. See Section 4 for selecting each type of particle test to be conducted. The SAP should include a list of test types, in tabular form, that includes at a minimum the following columns:

- Type of test (amount, grain size, chemical, mineral content)
- Sample collection method (i.e., grab or composite)
- Container type
- Volume or amount required
- Preservation
- Laboratory performing testing

U.S.EPA, ASTM, or other analysis protocols should be included in this section (see Section 9).

5.4 Data Quality Objectives (DQOs)

This section should specify the project goals and objectives, key project parameters, and the DQOs that were deemed appropriate for the project. See Section 2 for

guidance on the development of DQOs. The SAP should also describe the process by which data produced by the study are evaluated to provide a reference point from which a program-consistent QA/QC evaluation can be performed (see Section 8).

5.5 Field Equipment Maintenance

This section should include specific information concerning the maintenance of all sampling equipment. At a minimum, all equipment should be maintained according to manufacturer specifications. The following is a list of items that typically require regular maintenance:

- Passive sediment sampler – filters checked / replace
- Flow measuring device - calibrate, check battery and check/replace desiccant
- Rain gauge - calibrate and check for debris
- Portable field instruments (e.g., pH meter) – calibrate

Container and equipment cleaning should also be covered in this section of the SAP (see Appendix E in Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition) for guidance on sample bottle and equipment cleaning procedures). In addition, if equipment or sampling locations is located in a confined space, this section should include a discussion on the acceptable confined space entry procedures. See Section 6 and Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition) for guidance on the selection of sampling methods and equipment and detailed equipment installation and maintenance guidance.

5.6 Monitoring Preparation and Logistics

This section should describe the necessary pre-sampling preparations including:

- Weather tracking (if sampling is storm event driven)
- Storm action levels (if sampling is storm event driven)
- Communication/Notification Procedures
  - Telephone tree
- Sample container order
  - Sample container labeling
- Field equipment preparation
  - Inventory
  - Inspect

- Calibrate
- Charge batteries
- Check/replace desiccant

See Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition) for monitoring preparation and logistics guidance.

5.7 Sample Collection, Preservation, and Delivery

This section should provide detailed guidance on standard operating procedures for field personnel (i.e., a concise, useable guide for sampling activities). At a minimum, this section should include:

- Description of clean sample handling techniques
- Sample collection methods to be used at each location
- Field measurement equipment (e.g., pH meter) and methods to be used at each location
- Field equipment that will be required for monitoring at each station (includes a checklist so field people can confirm they have everything they will need before proceeding to the sampling location)
- Sample labeling procedures (site name/code, sample date and time, etc.)
- Sample compositing and splitting procedures (including testing prioritization for instances of insufficient sample volume)
- Procedures for collecting and labeling field blanks and duplicate samples
- Forms and procedures for documenting sample collection and field measurements
- Sample preservation and handling procedures
- Laboratory communication procedures, points of contact, and phone numbers
- Procedure for sample shipment or delivery to laboratory
- Details on completing chain-of-custody forms

See Sections 6 and 7 for detailed sample collection, preservation, and delivery guidance.

5.8 Quality Assurance/Quality Control

The QA/QC section should focus on QA/QC procedures necessary for field activities, such as field procedures and collection frequencies for the following:

- Laboratory duplicates
- Field blanks
- Equipment blanks

QA/QC sample collection frequencies are best presented in a QA/QC sample collection schedule table with a column for each event and a row for each site.

Laboratory QA/QC should be discussed in an appendix and should include the frequency and type of laboratory QA samples (e.g., laboratory duplicates, split samples, and bottle blanks), data reporting requirements (electronic and hard copy) and corrective actions. See Sections 8 and 9 for detailed QA/QC guidance.

5.9 Laboratory Sample Preparation and Test Methods

This section should describe the activities to be conducted by the laboratory, including sample preparation procedures. A table containing the following information should be presented:

- Analytical methods
- Reporting limits
- Reporting units
- Holding time
- Constituent name
- Laboratory QA/QC

See Section 9 for laboratory sample preparation and particle test methods guidance.

5.10 Data Management and Reporting Procedures

This section should describe how the data generated from the laboratory and field measurements are to be handled, evaluated, and reported. It should address:

- Data validation (QA/QC review in light of project DQOs, per procedures specified in the DQEP)
- Electronic data transfer

- Filing of electronic and hard copy data
- Data analysis (e.g., statistical evaluation, etc.)
- Reports (e.g., quarterly, annual, end of project)

At the beginning of the project, the field and laboratory personnel should review the entire SAP to obtain an overview of their respective roles and responsibilities. Before each sampling event, the field personnel should review the sampling methods section in detail, and the laboratory personnel should review the laboratory sample preparation and methods section. See Section 8 for QA/QC data evaluation guidance.

Efficient data storage, retrieval, and transfer methods should be established prior to initiation of any monitoring activities, including those to support particle studies. Suggestions are provided in the Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition) to guide Caltrans contractors and district personnel in the development of a reliable and useful data management system. Data gathered during particle studies will be incorporated into the Caltrans Statewide Stormwater Quality Database. Specific data reporting protocols for particle results are outline in Section 10.

5.11 Health and Safety Plan

Storm water and field monitoring involves activities that have the potential to adversely affect the health and safety of field personnel. Monitoring field crews often work in wet, poor-visibility conditions. Sampling sites may be located along streets or stream channels, or in remote, poorly lit areas, and may require access on a 24-hour basis. Workers may be exposed to traffic hazards, confined spaces, biological hazards, hazardous materials, fast-moving storm waters, and slippery conditions. Besides monitoring activities during storm events, monitoring equipment installation and maintenance activities may also take place under these conditions.

The information contained herein is for guidance only, and does not supersede or otherwise change any applicable state, local, or agency health and safety requirements or programs.

The general steps in HSP development for a given storm water monitoring project are listed below:

- Assign a health and safety officer to oversee all health and safety activities. This officer must be familiar with all applicable health and Safety requirements as well as being familiar with field sampling work.
- Write concise descriptions of all of the field activities that will be included in the program.

- Identify and evaluate the potential physical, chemical, and biological hazards associated with each activity.
- Specify the measures to be employed to reduce the health and safety risks associated with the identified hazards.
- Specify health and safety training and documentation requirements.
- Develop an emergency response/contingency plan.

Each of these steps is described in Appendix D of the Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition). Figure 5-2 contains an example outline for a project-specific HSP.

1.0 Introduction

2.0 Project And Safety Personnel

3.0 Site Information

4.0 Work Activities Covered By Health And Safety Plan

5.0 Hazard Assessment
- 5.1 Chemical Hazards
- 5.2 Confined Spaces
- 5.3 Physical Hazards
- 5.4 Biological Hazards

6.0 General Health And Safety Requirements
- 6.1 Employee Clearance
- 6.2 Site Safety Meetings
- 6.3 Accident Reporting
- 6.4 Prohibited On-Site Activities
- 6.5 Communications

7.0 Site-Specific Health And Safety Requirements
- 7.1 Special Medical Tests
- 7.2 Special Training
- 7.3 Physical Hazards
- 7.4 Hazardous Materials Identification And Protection
- 7.5 Confined Space Entry
- 7.6 Traffic Control
- 7.7 Personal Protective Equipment
- 7.8 Site Illumination
- 7.9 Biological Hazard

8.0 Emergency Response Procedures
- 8.1 Hospital Information
- 8.2 Emergency Route to Hospital
- 8.3 First Aid & Related Equipment

Figure 5-2
A Typical Outline for a Health and Safety Plan

Section 6
Sediment Sample Collection

Particle monitoring programs may require the collection of sediment samples. These samples will used to characterize the sediments that are deposited in BMPs, drainpipes, and inlets in terms of grain size, mass, chemical and mineral content, and loads (numbers and mass). Both composite and grab samples may be collected.

Particle monitoring studies need to be designed so the collected samples are representative of all sediments within a deposit. Ideally, this means collection of depth-based composite samples for sediments samples. Accumulated sediments may vary both laterally and vertically throughout the cross section of the deposit. Layers of sediment representing different runoff events may form in the deposit. Heavier particles may drop out of suspension first and accumulate in a different location than smaller or less dense particles.

The following are basic sediment sample collection and handling elements required during particle monitoring:

- Personnel Safety
- Sample Collection Methods
- Sampling Equipment and Containers
- Clean Sampling Techniques
- Sediment Sample Collection
- Composite Sediment Sample Collection
- Sample Representativeness Evaluation
- Sample Splitting
- Sample Preservation and Holding Time
- Sample Delivery/Chain of Custody

These elements are described below to provide sediment sample collection and handling guidance for field personnel engaged in storm water monitoring.

6.1 Personnel Safety

Before samples are collected, personnel must demonstrate these tasks can be safely performed at each sampling location. As discussed in Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition), personnel safety should be considered when selecting monitoring sites. Adherence to the following recommendations will minimize risks to sampling personnel:

- At no time during storm conditions or when significant flows are present should sampling personnel enter a manhole or standpipe.
- Field crews comprised of at least two people should be available for all fieldwork to be conducted under adverse weather conditions, or whenever there are risks to personal safety (Photo 6-1). Additional members may be required for confined-space entry and work performed near active highway lanes.
- Appropriate traffic control measures need to be applied in accordance with encroachment permits and or District directions. Personnel must be trained regarding appropriate traffic control measures. If appropriate, a traffic control plan should be developed for each site and included in the sampling and analysis plan prior to conducting sampling events.
- Only personnel properly trained and equipped for confined space entry may conduct a "confined" space entry; this applies to both the entrant and the observers.
- When appropriate, an encroachment permit must be filed with the local Caltrans district.

Photo 6-1. Two-person field crew working together

6.2 Sample Collection Methods

Sediment samples can be collected to represent a single location in a deposit (i.e., "grab" sample) or the entire deposit (i.e., "composite" sample). A grab sample is essentially a one-time collection of a sample amount adequate to perform the intended analyses. A composite sample is comprised of some number of individual sample aliquots or grab samples mixed together. For sediment monitoring, this usually refers to a series of samples collected over a defined portion of the deposit.

Both composite sampling and grab sampling are appropriate for particle sample collection, depending on the study objectives. The advantages and disadvantages of each sample collection method in terms of particle testing are provided in Table 6-1.

Composite Sampling. Manual and passive sampling are the two methods of composite sediment sample collection. The manual method uses hand-operated equipment to remove a sample or a series of samples from the sediment deposit. The passive method applies equipment designed to filter sediment from the runoff stream. Section 10 of the Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition) provides a description of manual compositing techniques.

Table 6-1
Advantages and Disadvantages of Grab and Composite Samples

Sample Type	Advantages	Disadvantages
Grab	▪ Require a minimum of equipment. ▪ Provide a measure of point-specific or instantaneous levels. ▪ Variations and changes are not masked by dilution with other samples.	▪ The chances of detecting a change in particles would depend on the spatial coverage and number; the probability of missing a change is high.
Composite	▪ The sample is collected over a greater spatial coverage than grab samples. ▪ Can provide a measure throughout a deposit	▪ Subtle changes may not be detected because they may be masked by dilution from other samples collected to develop the composite.

Grab Sample Collection. A grab sample is an individual sample collected at one specific site at one point at a location. Analysis of a grab sample provides a "snapshot" of sediment characteristics. Grab samples are most often collected using manual methods. Grab sediment samples for particle testing can be collected directly into the container that will be used in the laboratory or an intermediate container may be used to fill the sample container.

6.3 Sampling Equipment and Containers

For particle studies, field personnel may be required to collect composite sediment samples and/or grab sediment samples. It is important to use the appropriate sample containers and equipment for collection of sediment samples. Improper containers and equipment can introduce contaminants and cause other errors, which can invalidate the data. For example, chemicals may leach from the containers into the sample.

Photo 6-2. Example of a sediment sample container

Equipment and containers used in the collection of sediment samples for particle testing must be handled with care to minimize the possibility of contamination. Procedures need to be followed that maximize the ability of sampling personnel to collect samples reliably and with minimal sample contamination.

6.3.1 Selection of Sample Equipment

Selection of the most appropriate sampling equipment will depend upon study objectives, sampling logistics, and what is known about possible constituents at each site.

For all collection efforts, sampling devices must be made of chemical-resistant materials that will not affect the quality of the storm water or sediment sample. In general, suitable sampling devices should be constructed of: Teflon, glass, stainless steel, or polyethylene. These materials are known to be the most inert in terms of adsorption or desorption of compounds. It is important to evaluate each component of the sampling device (e.g., bottle lids, connections, spoons) for possible sources of sample contamination. For example, latex and neoprene rubber tubings should be avoided because latex is organic and neoprene rubber may contain trace metals. Butyl rubber seals may also contribute organics to the sample.

If information is available regarding the targeted constituents at a given site, this should guide the selection of sample containers. For example, if metals are suspected it is more appropriate to collect samples in polyethylene containers. At sites where organics are of concern, glass is preferred over polyethylene. Selection of appropriate sample containers for a given particle study should be evaluated and discussed with the laboratory prior to initiation of the study.

6.3.2 Sediment Sampling Equipment

Key equipment required to collect sediment samples include are presented for both manual and passive collection methods.

Manual Collection:

- Grade rods
- Core samplers
- Spoons, scoops and shovels
- Sample bottle(s)

Passive Collection:

- Particle trapping device
- Filters with structural support such as trays and boxes

The manual sampling equipment can include hand-operated items such as grade rods, core samplers, scoops and shovels that are designed to measure the depth of the sediment deposit or collect a physical portion of the deposit. These types of equipment are relatively inexpensive and easy to maintain. Manual sampling equipment which comes in direct contact with the sample during or after collection must be compatible with the specific constituents to be analyzed, as discussed previously.

Passive sampling equipment is designed to trap sediment and create deposits that can be collected or sampled using manual methods. Devices to trap the coarse-grained or

heavy material include detention ponds, drain inlets with sump bottoms, and sand traps. Any device that lowers the velocity of the flow and causes a portion of the suspended particles to settle out can be applied. An example of one such device is shown in Figure 6-1. This trapping device is a double barrel sand trap. Storm water runoff is directed through a series of two barrels where suspended particles are allowed to settle to the bottom before being discharged. Samples of the sediments that accumulate on the bottom of each barrel are collected using manual methods.

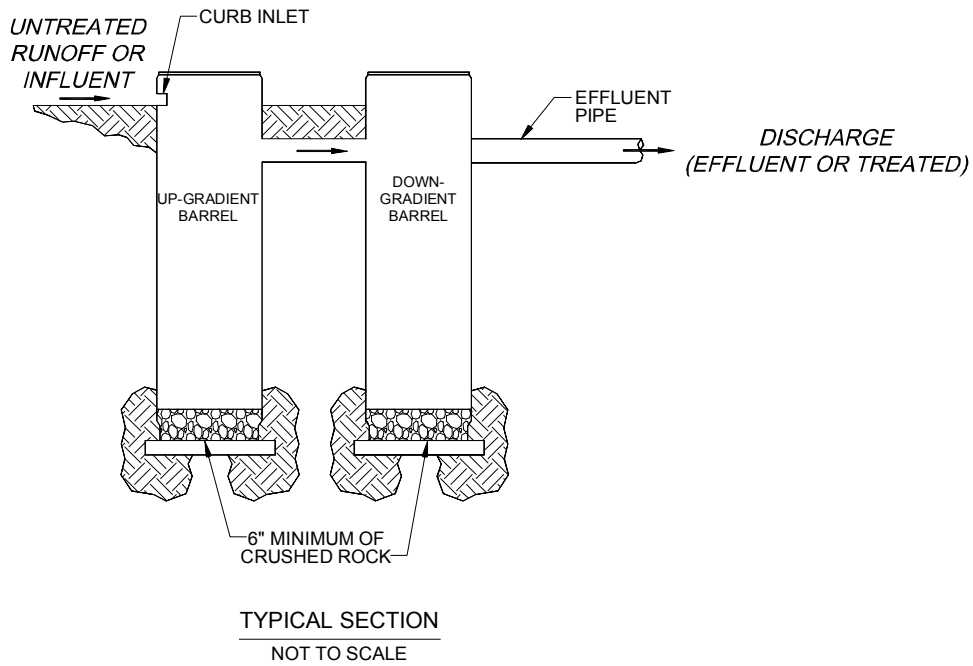
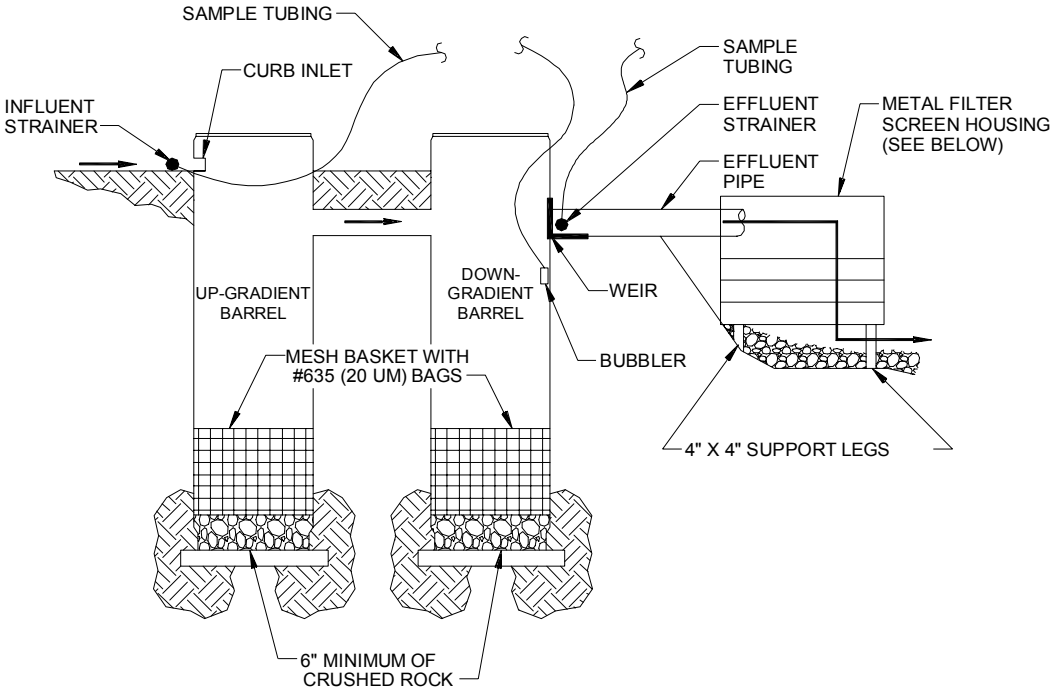
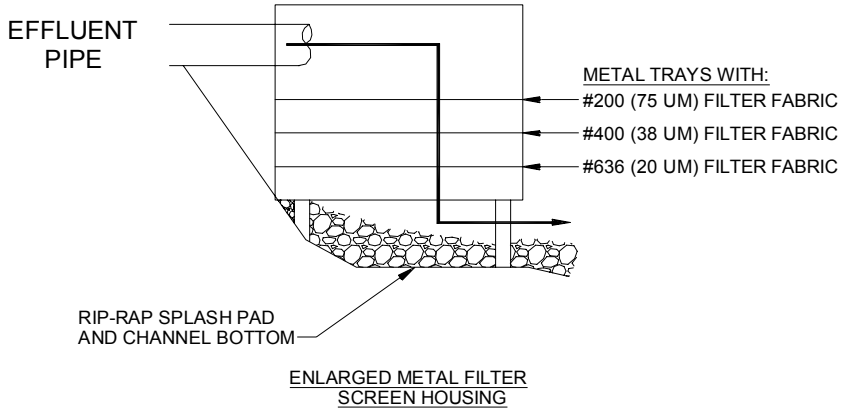


Figure 6-1
Example of a Sediment Trapping Device (Double Barrel Sand Trap)

For particles that do not readily settle out of suspension, filtering can be applied to collect them. Filtering devices are designed to direct the flow through a filter or a series of filters, trapping the desired sediment on the surface of each filter.

An example of a passive filter system is shown in Figure 6-2. Filters were applied to a double barrel sand trap facility shown in Figure 6-1. Filters in the shape of bags were anchored to the bottom of each barrel (Photo 6-3). This design provided a clean boundary at the start of the monitoring program. All the material that settled out of suspension, fell into the bags. The filters allowed the water to pass through and drain out of the bottom of the barrel so the operation of the trap was not compromised. But, the filters trapped all sediment larger than the pore size of the filter fabric. The bags were then retrieved on a regular basis (*i.e.*, per event, weekly, seasonal) and all the accumulated sediment removed or manual sampling was performed with the bags providing the lower boundary.





TYPICAL SECTION

NOT TO SCALE

Figure 6-2
Schematic of Double Barrel Sand Trap with Passive Sediment Collection System

Photo 6-3. Barrel with Filter Bag

The discharge from the sand traps or effluent was directed to a box with a series of stacked trays holding filters. Photo 6-4 shows an example of this design. The discharge flowed onto the top tray and through to the next one before exiting out of the bottom. The top filter had the largest pore size followed by filters with smaller pores sizes with the bottom filter having the smallest. This graduated filter design allowed the top trays to filter out the coarsest material and allow the finer materials to pass through. This design was implemented as a means to minimize clogging of the filters, which would cause the flow to bypass the system. This filter box design can be applied on its own or in conjunction with water quality monitoring.

Photo 6-4. Filter Box with Three Trays

The filters are prone to clogging. Regular cleaning or swapping out with clean filters is required to prevent bypassing. Complete capture of the entire runoff event may not be possible due to this clogging problem. Sediment collected on the filters may only represent a portion

Photo 6-5. Filter Box with Single Bag

of the runoff or sediment load. The filter box design can be modified to hold a single bag filter (Photo 6-5) as another means to reduce the impacts of clogging.

Figure 6-2 also shows how a passive sediment collection system can be combined with automatic water sampling and flow monitoring. The equipment associated with the autosamplers (strainers and sample tubing) and flow monitoring (weir and bubbler) is shown in relation to the passive monitoring equipment.

6.3.3 Sample Containers

Polyethylene, glass, or plastic containers (Photo 6-2) may be appropriate for sediment samples, depending on the objectives of the study, sampling logistics, and what is known about possible constituents present at each site. The selection of the appropriate sample container type should be discussed with the laboratory prior to initiation of the study. Refer to Table 9-1 in Section 9 for additional information.

It is important to keep extra sample bottles available in case bottles are contaminated or damaged. Additional bottles may also be needed when large volumes of sample are required by the grain size tests.

6.3.4 Equipment and Container Cleaning and Handling

Before samples are collected, all sampling equipment and containers are cleaned in a laboratory using appropriate solvent rinses, deionized water and/or other methods (e.g., high temperatures). The laboratory is responsible for generating acceptable sample container blanks to demonstrate that the sampling equipment and containers are free from trace metals and organics contamination before they are delivered to field sampling personnel. An acceptable blank is one that is free from particles and other chemicals. Section 8 provides additional information on collection of equipment blanks.

New plasticware used for sample collection does not require thorough cleaning before use. New glass sample containers should be rinsed before use according to the protocol outlined in the container rinsing and labeling section below.

New glassware must be soaked overnight in 10% acid and rinsed well in deionized water and dilution water. All non-disposable sample containers and other equipment must be washed after each use to remove contaminants as described below:

1. Soak 15 min in tap water and scrub with detergent, or clean in an automatic dishwasher.

2. Rinse twice with tap water.

3. Carefully rinse once with fresh, dilute (10%, V:V) hydrochloric or nitric acid to remove scale, metals and bases. To prepare a 10% solution of acid, add 10 mL of concentrated acid to 90 mL of deionized water.

4. Rinse twice with deionized water.

5. Rinse once with full-strength, pesticide-grade acetone to remove organic compounds (use a fume hood or canopy).

6. Rinse three times with deionized water.

After cleaning, sample containers and laboratory-cleaned sampling equipment are handled only while wearing clean, powder-free nitrile gloves. All laboratory-cleaned sampling equipment is double bagged in clean zip-lock plastic bags for storage or shipment. Clean bottles are stored in a clean area with lids properly secured.

6.4 Clean Sampling Techniques

Caltrans storm water monitoring projects employ "clean" sampling techniques to minimize potential sources of sample contamination, particularly from trace pollutants. Experience has shown that when clean sampling techniques are used, detected concentrations of constituents tend to be lower. Clean sample collection techniques that should be followed during the collection of storm water samples for particle monitoring are described below. More extensive clean sampling techniques may be required under certain conditions, such as monitoring to assess receiving water impacts.

Photo 6-6. Example of using gloves when collecting a sample

Extreme care must be taken during all sampling operations to minimize exposure of the samples to human, atmospheric, and other potential sources of contamination. Care must be taken to avoid contamination whenever handling containers, lids, and sampling equipment. Whenever possible, grab samples should be collected by opening, filling and capping the sample container as quickly as possible, to minimize exposure to airborne particulate matter. Additionally, whenever possible, samples should be collected upstream and upwind of sampling personnel to minimize introduction of contaminants.

To reduce potential contamination, sample collection personnel must adhere to the

following rules while collecting sediment samples:

- No smoking
- Always wear clean, powder-free, nitrile or similar surgical-quality gloves when handling sample containers as shown in Photo 6-6
- Never sample near a running vehicle. Avoid parking vehicles in immediate sample collection area (even non-running vehicles)
- Minimize the amount of time any sample container is left open
- Do not set lids down where they may accumulate contaminants
- Prevent foreign material (blowing dust, leaves, etc.) from entering any open sample container
- Never touch the inside surfaces of sample containers and lids, even with gloved hands
- Do not eat or drink during sample collection
- Do not breathe, sneeze or cough in the direction of an open sample container

6.5 Sediment Sampling Techniques

Sediment sampling may be required for studies that focus on the treatment effectiveness of BMPs and characterizing accumulated solids. Sampling can be performed to define physical properties of volume, amount (weight), and grain size of the accumulated sediments. Sample collection can also be performed for chemical analyses. A number of methods have been developed to collect the require samples. These methods are discussed below.

6.5.1 Volume of Accumulated Sediments

Volume measurements can be determined by first defining the dimensions of the facilities where the sediments are expected to accumulate, such as the floor of drain inlets or chambers in BMPs. These measurements should be made when the facility is clean and free of sediment and other materials. As the sediment and other materials accumulate, only the depth of this material needs to be measured. The total volume is then calculated by multiplying the measured depth by the other established dimensions (length, width, or diameter).

Photo 6-7. Collecting a depth of sediment measurement

A single depth measurement at a given facility may not be representative of the average depth. Depending on the flatness of the surface, multiple measurements may be required to accurately represent the depth. Flat surfaces will require fewer measurements than uneven surfaces. For example, 12 depth measurements were routinely collected at each drain inlet monitored for Caltrans Solids Transport and Deposition Study (Caltrans STDS 1998). However pilot studies conducted at the beginning of STDS found the number of depth measurements at a given site did not have a significant impact on the accuracy of the average depth. A whole range of measurements (3 – 24) generated similar average depth readings due to the flatness of both the surface material and inlet floor.

Depth measurements can be collected directly with a measuring rod. This method requires the rod penetrate the entire depth of material. This method may also require entering a confined space and standing on the accumulated material to take a reading.

The depth can also be determined by an indirect method (Photo 6-7). This method entails measuring from a fixed point to the surface of the accumulated material. This distance is then subtracted from the distance from the fixed point to the floor of the facility to calculate the depth of the material. This method will allow measurements to be collected outside of a confined space and minimize disturbing the accumulated sediment. Again multiple measurements may be required for an accurate representation of the average depth.

6.5.2 Sediment Amount

Collecting sediment samples to determine the amount or weight can be performed using one of two methods. The first method simply removes all material and separates out litter and organic material. The remaining sediment is than weighed to determine the total weight.

Often, the amount of sediment and accumulated material may be too large to handle easily. Under these circumstances, the weight needs to be estimated using the *in situ* volume and a dry density measurement. After the *in situ* volume is calculated using one of the methods discussed above, several representative samples of the entire deposit are collected using a core sampler (discussed below). The core sample will allow the volume of each sample to be determined. All litter and organic material are removed and the remaining sediment is dried and weighed. The dry density is calculated by dividing the total dry weight by the sample volume. The average of the

all the dry densities at a single site is then applied to the *in situ* volume to estimate the total dry weight of the entire deposit.

6.5.3 Manual Sediment Sampling

Sediments samples collected for particle size and chemical analyses under Caltrans studies will most likely come from drainage systems where sediments accumulate (inlets and pipes) or BMPs that are designed to trap sediments. There are several basic methods available for collecting a physical sample at these facilities. They include:

Core Method. A metal or plastic tube is used to push through the entire depth of the sediment deposit in the vertical direction to extract a core sample (Photo 6-8).

Depth-Integrate Excavation. A spoon or shovel (metal or plastic) is used to excavate a sample from the entire profile of the sediment deposit.

Scoop Method. A scoop device (metal or plastic) is used to collect random samples of the sediment deposit.

Photo 6-8. Collection of a core sample

In Situ X-Ray Fluorescence (XRF) Method. A field-portable energy dispersive XRF spectrometer is used to analyze the surface of the sediment deposits for levels of selected metals only. Nutrients and other organic parameters cannot be measured with this method.

Selection of a sampling method will depend on the cohesiveness of the sediment, depth of the deposit, type of sampling, the desired degree of disturbance to the deposit, amount of litter and organic matter present, and access to the deposit. The applications and limitations of each method are presented in Table 6-2.

6.5.4 Passive Sediment Sampling

Sediments samples can also be collected by the passive method for weight, particle size, chemical, and mineral analyses. The passive method uses filters to separate the particles from the runoff. The runoff stream is directed to pass through a filter or a series of filters and the all the particles larger than the pore size of the filter remain on the upstream side of the filter (Photo 6-9). A portion of the particles smaller than the pore size may also be become entrapped as well.

Photo 6-9. Filters with collected sediments

Table 6-2
Applications and Limitations of Particle/Sediment Sampling Methods

Sampling Method	Applications	Limitations
Core	▪ Cohesive soils ▪ Depths > 5 cm ▪ Soil profile required ▪ Minimal impact to deposit ▪ Sampling rod extends reach	▪ Shut-off cap required in sand, gravel, or water ▪ Presence of litter and plant material can create problems
Depth-Integrated Excavation	▪ Cohesive soils ▪ Depths < 30 cm ▪ Soil profile required ▪ Locations with limited access to deposit	▪ Disturbs relatively large area ▪ Sample collection may require surface to be disturbed
Scoop	▪ All soils ▪ Depths < 50 cm, unless the entire deposit is removed ▪ Locations with limited access to deposit	▪ Disturbs relatively large area ▪ Does not maintain the profile ▪ Sample collection may require surface to be disturbed
In situ X-Ray Fluorescence	▪ Analysis of metals only ▪ No disturbance to deposit ▪ Clear overhead access to deposit	▪ Presence of litter and plant material can create problems ▪ Access

The filters are than collected and dried (Photo 6-10). The tare weight of the filter is subtracted from the total weight to determine the dry weight of the solids. The dried solids are removed from the filter for use in grain size, chemical, and mineral analyses.

Photo 6-10. Filters being allowed to drain and dry

Filters can be deployed for any length of time. However, they need to be watched to minimize the chances of clogging which may cause the runoff to bypass around the system. All the materials carried along with storm water (e.g., sediment, gravel, litter, and leaves) can clog a filter very quickly if the filter has not been sized to accommodate the anticipated runoff volume and material. Filters have to be exchanged with new clean filters as solids become entrapped on their surface.

The use of a multi-filter system with graduated pore sizes can be applied to

reduce clogging. The filters should be arranged so the filter with the largest pore size is first and the filter with the smallest pore size last. A screen can be included to remove very large materials prior to the filters.

The smaller the pore size, the faster the filter will clog with debris. Pore sizes less than 20 µm are not practical for field installations. The field installations depend on gravity to force the runoff through the filter. Filters with pore sizes less than 20 µm typically required some force other than gravity to push the runoff through at a reasonable rate, such as a vacuum pump.

6.6 Composite Sediment Sample Collection

The sediment sample collected by the passive method can be considered a composite sample. The sample is representative of an entire runoff event, time period, or season similar to flow-weighted composite water samples.

For manual sampling, the composite sediment sample is made up of multiple sub-samples collected over some spatial range, a single sample collected over a vertical profile, or both. Manual composite samples are typically collected from a single location on a given day, not from multiple sites or on multiple days.

Development of a manual composite sample is relatively straightforward. Each subsample is placed in the same mixing bowl and thoroughly mixed together. Either the entire mixture or some portion is then distributed to the sample containers for transport to the laboratory. Profile or core samples are composited the same way. The sample is thoroughly mix so no distinct layers remain and then distributed to the sample containers. Multiple core samples can be mixed together to develop a single composite sample. During the mixing process, litter and other materials can be separated out so only the sediment remains.

Variation in the sediment characteristics (particle size and chemical content) is very common within individual sampling sites. Sufficient number of subsamples must be collected so that the composite sample is representative of the site.

If multiple samples will be collected over a period of time, a pilot test is recommended to estimate the variability and define the minimum number of subsamples required. At each site, a series of subsamples should be collected and analyzed individually. The variation among the values derived from subsets will indicate the minimum number of subsamples to collect for the sample to be representative. The STDS found the minimum number was six subsamples for sediment that accumulated in drain inlets (Caltrans, 1998).

The use of composite samples is an excellent estimate of the mean and helps to hold down costs. However, compositing only provides limited information on variability within a study area and may create statistical problems when testing hypotheses by limiting the size of the database. When planning a particle or water quality study, the use of composite samples have to be considered carefully in order to populate the

database with a sufficient number of points. Collecting composite samples over multiple events or analyzing multiple subsamples from one or more events can accomplish this.

6.7 Sediment Sample Representativeness Evaluation

Each collected sample or measurement must be evaluated for their representativeness to determine whether they meet the minimum acceptable criteria established for the project. Sediment samples not meeting these criteria are generally not tested. However, the Caltrans Project Coordinator should be consulted to make the decision whether or not to analyze the samples.

For volume measurements, a minimum number of depth measurements along a standard grid should be established for each site. These criteria will be based on pilot studies and relative variability among the individual sampling points. Low variability may reduce the number of depth measurements, while high variability may increase the number required in order for the average of all measurements to be representative of the mean depth.

For amount or weight measurements, there are several criteria to establish representativeness. If the deposit is removed and weighed, the entire deposit needs to be collected and none left behind. If subsamples are collected for density measurements, a sufficient number of samples must be collected that represent various locations within the deposit, such as one for every square foot. The subsamples must include the entire vertical profile, not just a portion. The weight must be a dry weight, so each sample must be dried at a standard temperature and time period.

Samples collected for particle size and chemical analyses have similar criteria as the weight measurements. Multiple samples should be collected at each site to account for spatial variability and each sample should include the entire vertical profile.

6.8 Composite Sample Splitting

Composite sediment samples are developed in a single mixing bowl, by the laboratory or the sampling team, and then divided into individual sample containers for analysis (to limit contamination it is recommended that splitting be conducted by the laboratory). When a composite sample duplicate is required, the sampling team will be required to split the composite sediment sample into two containers to generate a subsampling duplicate. As with field duplicate samples (replicate samples collected simultaneously in the field), subsampling duplicates (replicate samples generated from a single composite sample) should be submitted to the analytical laboratory “blind” (labeled using a pseudonym site name). Below is an example of a composite sample splitting procedure:

1. Label sample storage containers for specific analyses.

2. Wear clean powder-free nitrile gloves when handling the mixing bowl, mixing utensils, containers and lids.

3. Clean all items that will contact the sample using protocols presented in Appendix E in Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition).

4. Use clean bowls to composite and mix samples.

5. Use clean utensils like spoons to stir the sample to create a homogeneous mixture.

6. Transfer samples from the mixing bowl to the sample containers and duplicate containers using a sample splitter device or an alternating distribution process; one spoon full to the sample and the next spoonful to the duplicate. Follow either procedure until both sets of containers are full.

6.9 Sediment Sample Preservation and Holding Time

6.9.1 Preservation

All sediment samples for chemical analyses are kept on ice or refrigerated to 4° C from the time of sample collection until delivery to the analytical laboratory. Samples should be placed in an ice chest with ice immediately following collection.

In addition to keeping samples cool it is also important to minimize the exposure of the samples to direct sunlight, as sunlight may cause chemical and or biological alteration of the sample, resulting in unreliable results. Use of opaque plastic or amber glass bottles should be used to reduce light exposure and all samples should be covered or placed in an ice chest with a closed lid immediately following collection.

6.9.2 Holding Time

When more than one grab sediment samples are collected or a composite sediment sample is collected, sample holding time begins when the last grab sample in a series is taken. The Chain-of-Custody (COC) form should clearly indicate the time of sample collection.

6.10 Sample Delivery and Chain of Custody

For delivery to the laboratory, all sediment sample containers are placed inside coolers, the containers are well packaged (i.e., with bubble wrap, foam, etc.), and cooler lids are secured with packaging tape. All sediment samples for chemical analysis should be kept on ice, or refrigerated, from the time of onset of sample collection to the time of receipt by laboratory personnel. Delivery coolers should be packed with ice (wet ice is preferable to gel ice).

The field crew must coordinate activities with the laboratory(s) performing any of the sediment analyses. The sampling crew must contact the laboratory prior to sample

collection to provide some indication as to when the laboratory should expect to receive the samples. This notice should be provided as soon as possible (i.e., within the next 72 hours), and should be followed by notice to the laboratory once sample collection has commenced.

The sampling team fills out COC forms for all sediment samples submitted to the laboratory. The purpose of COC forms is to keep a record of the transfer of sample custody, and requested analyses. Sample date, sample location, and analysis requested are noted on each COC, including specification of lab quality control requirements (e.g., laboratory duplicate samples; see Section 8). Any special instructions for the laboratory should also be noted. Project-specific COCs that include standard information (e.g., contact information, constituents and methods, and special notes) are recommended. Copies of COC forms are kept with field notes in a field logbook. COC forms should be checked to be sure all analyses specified by the sampling plan are included. Review of the COC forms immediately following a sampling event gives the data reviewer a chance to review the field crews' requests and then to notify the laboratory of additional analyses or necessary clarification.

6.11 Flow and Precipitation Monitoring

Flow and precipitation measurements provide useful information to support storm water runoff sample collection and data interpretation. Flow measurement is necessary for accurate water sample compositing. Flow and concentration data are used to calculate pollutant and particle loads. Flow and precipitation data can be used to understand site hydrology. Other important components of successful collection of storm water runoff samples include system integration, system command/control, and remote communication. Each of these components is discussed in detail in Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition).

Section 7
Water Sample Collection for Particle/Sediment Monitoring

Particle monitoring programs may also collect water samples of the runoff. These water samples are typically analyzed for number of particles per grain size and total weight of the particles. The results can be expressed as a concentration on a per liter basis and then applied to flow data to calculate loads. Water samples may also be collected for analysis of grain size based on mass (sieve/hydrometer method) or chemical content but the required sample size may be impractical as discussed in Section 4. Analyses of water samples for total suspended solids (TSS), suspended solids concentration (SSC), and turbidity can also provide information for a particle characterization study. Both composite and grab samples may be collected.

Particle monitoring studies should be designed so the collected samples are representative of runoff quality throughout a given storm event. Ideally, this means collection of flow-proportioned composite samples throughout the runoff hydrograph for water samples.

Particles suspended in runoff may vary both laterally and vertically throughout the cross section of flow. For instance, light particles may be present in significant amounts near the water surface, while heavier or denser particles are often concentrated near the bottom of the conveyance. The particle concentrations may vary with time as well. Concentrations may be higher in the first hour or two of runoff; this is often referred to as a "first flush" effect. During the course of a storm, rainfall intensity also may increase, raising runoff flow rates to the point where additional scouring may occur and more particles are mobilized, resulting in temporarily higher concentrations.

The basic water sample collection and handling elements required during collection of water samples for particle monitoring are listed below. These elements need to be considered when developing the SAP for the study. These elements are very similar to the elements discussed in for sediment sample collection in Section 6.

- Personnel Safety
- Sampling Equipment and Bottles
- Clean Sampling Techniques
- Grab Water Sample Collection
- Composite Water Sample Collection
- Flow Monitoring
- Composite Bottle Changing

- Sample Representativeness Evaluation
- Multi-bottle Compositing and Composite Water Sample Splitting
- Sample Preservation and Holding Time
- Sample Delivery/Chain of Custody

These elements are described in detail in Sections 9 and 10 of the Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition). This document provides water sample collection and handling guidance for field personnel engaged in runoff water monitoring. The Storm Water Monitoring Protocols document also provides guidance on two related topics required for all water-based monitoring:

- Installation and maintenance of monitoring stations that are equipped with automated monitoring equipment (Section 7 in the Storm Water Protocols)
- Storm water monitoring preparation and logistics (Section 9 in the Storm Water Protocols)

Section 8
Quality Assurance/Quality Control (QA/QC)

The quality of particle data is dependent on the manner in which samples are collected, handled, and analyzed. To demonstrate that the data meet project data quality acceptability limits or objectives, project specific DQOs should be included in the sampling and analysis plan (SAP) prior to implementing any particle monitoring study. The SAP should include QA/QC review procedures for both field and laboratory measures (see Section 5 and the QA/QC data evaluation discussion below).

The three major categories of QA/QC checks are accuracy, precision, and contamination. Accuracy is assessed by measuring percent recovery of a known quantity of analyte (e.g., via a matrix spike or laboratory control spike) and comparing it against prescribed acceptability limits. Calculating the relative difference between results for duplicate samples and comparing the relative percent difference (RPD) against prescribed acceptability limits assesses precision. Contamination is assessed using blank samples to identify sources of contamination.

Improved control of data quality is achieved by incorporating the following typical storm water monitoring QA/QC elements into the sample collection effort:

- Blank Samples
- Duplicate Samples
- Lab-Initiated QA/QC
- QC Sample Schedule
- QA/QC Data Evaluation

Each of these types of samples and the relevant responsibilities of monitoring field personnel as they pertain to particle monitoring are described below. This is then followed by a discussion of recommended minimum frequencies for the various types of QC samples and how the results of the field QC samples are then used to evaluate the quality of the reported data. A similar discussion for water-based samples can be found in the Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition).

Laboratory QA/QC for physical analyses of sediments (sediment amount and size fraction) generally does not apply. However, where applicable, all field QA/QC (described below) should be conducted for these parameters.

8.1 Blank Samples

Blanks are prepared to identify potential sample contamination occurring during field collection, handling, shipment, storage, and laboratory handling and analysis. Blanks are evaluated during various stages of the sampling and analytical process to determine the level of contamination introduced at each step. The collection and uses of the types of blank samples associated with particle monitoring field procedures are described below. "Blank sediment" refers to contaminant-free sediment provided by the laboratory performing the environmental and blank analyses. Typically, these sediments are either pure quartz sand or glass beads. The analytical laboratory should be consulted when selecting the source of the blank water and sediment.

8.1.1 Equipment Blanks

Before using sampling equipment for sample collection activities, blanks should be collected to verify that the equipment is not a source of sample contamination. Sediment monitoring programs that include chemical analyses normally include equipment blanks to check collection utensils (coring tubes, spoons, scoops, and shovels), mixing bowls, and sample containers. Equipment blanks are usually prepared at the beginning of the monitoring season. Equipment blanks are collected using clean techniques, prior to on-site sample collection, before the equipment has been contaminated by environmental sample sediment or other sources. A decontamination rinsate sample is prepared by pouring analyte-free water over the surface of sampling equipment after decontamination procedures have been performed. After collection, equipment blanks are capped, placed in an ice chest with ice or frozen packets, and delivered to the analytical laboratory in the same manner as environmental samples.

Equipment blanks are analyzed using the same methods as those used for normal sample analysis and submitted to the analytical laboratory "blind" (disguised as a regular environmental sample by labeling with a pseudonym).

To account for any contamination introduced by sampling containers, blanks must be collected for laboratory containers used for sample storage for metals analysis. A sampling container blank is prepared by filling a clean container with blank water which is then measured the concentrations of selected constituents (typically metals only for storage bottles). These blanks may be submitted "blind" to the laboratory by field personnel or prepared internally by the laboratory.

Collection of sample container blanks may not be required if certified pre-cleaned containers are used. The manufacturer can provide certification forms that document the concentration to which the containers are "contaminant-free"; these concentrations should be equivalent to or less than the program reporting limits. If the certification level is above the program reporting limits, 2% of the bottles in a "lot" or "batch" should be blanked at the program detection limits with a minimum frequency of one bottle per batch. A batch is a group of samples that are cleaned at the same time and in the same manner; or, if decontaminated bottles were sent directly from

the manufacturer, the batch would be the lot designated by the manufacturer in their testing of the bottles.

Decontamination rinsate blanks should be collected at a frequency of one per 20 samples, if applicable. Results are used to assess whether decontamination procedures are sufficient, and whether carry over of contamination from sample to sample has occurred.

8.1.2 Field Blanks

Field blanks are necessary to evaluate whether contamination is introduced during field sampling activities. The field crew, under normal sample collection conditions, prepares field blanks at some time during the collection of normal samples. Field blanks are prepared by filling a sample container with blank sediment, transporting the container to the field and processing the water through the same sampling procedures to be used for sample collection. For grab sample collection, grab sample field blanks should be prepared by pouring a sample directly from the bottle of blank sediment, into the grab sample containers. Grab sample blanking should imitate environmental sampling as closely as possible by using scoops, clean intermediate containers, and other clean equipment in the same manner.

Field blanks are collected at a frequency no less than once per field sampling team per sampling season. Additional blanks should be collected when there is a change in sampling personnel, equipment, or procedures. It may also be desirable to prepare field blanks prior to any actual sampling events as an advance check of the overall sampling procedures. Scheduling field blanks is discussed further in Section 8.4.

8.2 Duplicate Samples

Analytical precision is a measure of the reproducibility of data and is assessed by analyzing two samples or measurements that are intended to be identical. Any significant differences between the two data points indicate an unaccounted-for factor or a source of bias. There are typically two types of duplicate samples that require special sampling considerations: field duplicates and laboratory duplicates.

The duplicate test is evaluated by calculating the RPD between the two sets of results for each constituent. This serves as a measure of the reproducibility, or "precision" of the sample collection and analysis. Calculation of RPD is discussed later in this section.

8.2.1 Field Duplicates

Field duplicates are used to assess variability attributable to collection, handling, shipment, storage and/or laboratory handling and analysis. Field duplicates should be collected for sediment volume measurements, mass estimates using density, particle size distributions analyses, and chemical analyses.

The procedures for collecting field duplicate samples will depend upon the field method being applied. There are two types of duplicates applicable to sediment samples. A split that is a subsample collected from a homogenized composite or grab sample, and a co-locate that is an additional subsample collected from near the location of a first grab subsample. All field protocols should be exactly duplicated with the same sets of equipment, to collect the duplicate sample simultaneously with or immediately following collection of the environmental sample.

When collecting duplicate composite samples, the following procedures should be used:

- Collect enough sample for both environmental sample analysis and field duplicate analysis (amount will be specified by the analytical laboratory) in one or more composite bottles.
- Splitting the composite samples as discussed in detail in Sections 6 and 7. Field duplicate samples should be split in the same manner as the environmental samples, and are taken in random order along with the environmental samples to assess the variability introduced during splitting and laboratory analysis.

Field duplicate samples should be submitted to the laboratory "blind" (i.e., not identified as a QC sample, but labeled with a different site identification than the regular sample).

8.3 Lab-Initiated QA/QC

The standard EPA methods require that the laboratory conduct certain QA/QC procedures. Following are the analytical QA/QC results that are normally reported.

8.3.1 Method Blanks

Method blanks (also called control blanks) should be run by the laboratory for each batch of samples to determine the level of contamination associated with laboratory reagents. A method blank is analyzed along with all aqueous and nonaqueous samples submitted for analyses. The method/reagent blank is processed through all procedures, materials, reagents, and labware used for sample preparation and analysis.

The laboratory prepares method blanks with laboratory reagents or blank sediment. An analytical batch is defined as samples that are analyzed together with the same method sequence and the same lots of reagents, and with the manipulations common to each sample within the same time period, or in continuous sequential time periods. Samples in each batch are to be of similar composition or matrix.

Results of the method blank analysis should be reported with the sample results. At a minimum, the laboratory should report method blanks at a frequency of 5% (one method blank with each batch of up to 20 samples).

8.3.2 Laboratory Control Samples

The Laboratory Control Sample (LCS) or Blank Spike (BS) is a quality control check sample (i.e., reference standard) that is carried along with the samples through the entire sample preparation/analysis sequence.

8.3.3 Laboratory Duplicates

Laboratory duplicates (also called laboratory splits) are used to assess the precision of the analytical method and laboratory handling. For the laboratory duplicate analysis, the analytical laboratory will split one sample into two portions and analyze each.

When collecting samples to be analyzed for laboratory duplicates, typically double the normal sample amount is required. This requires filling a larger size sample container, or filling two normal size sample containers, labeling one with the site name and the second with the site name plus "laboratory duplicate." Laboratory duplicate samples are collected, handled, and delivered to the analytical laboratory in the same manner as environmental samples.

8.3.4 Matrix Spikes/Matrix Spike Duplicate Samples

Matrix spike (MS) and matrix spike duplicate (MSD) analyses are used to assess the accuracy (MS) and precision (MSD) of the analytical methods in the sample matrix. A sample matrix spike is prepared by adding a known amount of the pure analyte to the environmental sample before extraction/digestion. The added analyte is the same as that is being analyzed for in the environmental sample. Background and interferences having an effect on the actual sample analyte will have a similar effect on the spike compounds.

The analytical laboratory prepares matrix spike samples by splitting off three aliquots of the environmental sample and adding the target analytes to two of the three environmental sample aliquots. The results of the analysis of the unspiked environmental sample are compared to the MS analysis results, and "percent recovery" of each spike is calculated to determine the accuracy of the analysis. The results of the MS analyses are compared to calculate RPD as an additional measure of analytical precision.

When collecting samples to be specified for MS/MSD analysis, typically triple the normal sample volume or amount is required. This will require filling a larger size sample container, or filling three normal size sample containers, labeling one with the site name and the other two with the site name plus "MS/MSD". MS/MSD samples are collected, handled, and delivered to the analytical laboratory in the same manner as environmental samples. Analytical laboratories often will perform MS/MSD analyses at no additional charge on a specified sample when a certain minimum number of samples are submitted for analysis.

8.3.5 Surrogate Spikes

For the analyses of organic compounds, every sample is spiked before extraction/analysis with a mixture of surrogate compounds which behave similarly, but are not identical to analytes potentially found in naturally-occurring sample matrices. The percent recovery of the surrogate compounds can be used as an indicator of accuracy of the analyses.

8.3.6 ICP Interference Check Sample (ICS)

To verify inter-element correction factors for inductively coupled plasma (ICP) analyses, the laboratory must analyze and report the results for an ICP Interference Check Sample at the beginning and end of each analysis run or a minimum of twice per 8 hours, whichever is more frequent, but not before initial calibration verification. The ICP Interference Check Samples are prepared and analyzed according to EPA Method 6010.

8.4 Quality Control Sample Schedule

Table 8-1 summarizes the recommended frequencies of quality control sample collection/ preparation for Caltrans particle monitoring studies. These frequencies are the minimum and may be increased depending on the nature and objectives of the study being undertaken or if QA/QC problems (e.g., contamination) are discovered. An adequate quality control sample schedule should be included in the analytical budget for the particle study.

A quality control sample schedule should be developed, included in the SAP, and followed closely by field personnel. The project quality control sample schedule should meet the minimum quality control sample frequency criteria over the term of the project. In some cases, quality control samples at one site may be applied to an analogous situation at another site. For example, if the same equipment and protocols are used at Site A and Site B, equipment blank checks at one site can be applied at both sites. The minimum frequency criteria must still be met; however, the quality control sample schedule should consider the location of each quality control sample to maximize coverage at all project sites. A quality control sample schedule should, at a minimum, indicate the types and frequency of quality control sample collection, site of quality control sample collection, and quality control sample pseudonyms for samples that will be submitted “blind” to the laboratory.

Table 8-1
Recommended Quality Control Sample Frequencies

Quality Control Sample Type	Minimum Sampling Frequency	Constituent Class
Field Duplicate	Once every 20 samples collected at a given site or once per sampling station per project, whichever is more frequent.	All
Lab Duplicate	Once every 20 samples collected at a given site or once per sampling station per project, whichever is more frequent.	All
Equipment Blank	Equipment blanks should be collected prior to each sampling season for each piece of equipment to be used for sample collection (bailers, pumps, and carboys).	Metals and other common contaminants. [1]
Container Blanks	Sample containers should be blanked every batch [2]; or manufacturer or laboratory-certified to concentrations below the reporting limits used for the sampling program.	Metals and other common contaminants. [1]
Field Blank	Once every 20 samples collected at a given site or once per sampling station per project, whichever is more frequent.	Metals and other common contaminants. [1]
Method Blank, Lab Control Samples	Once every 20 samples collected at a given site or once per sampling station per project, whichever is more frequent.	Metals and other common contaminants. [1]
Matrix Spike/Matrix Spike Duplicate, Surrogate Spikes	Once every 20 samples collected at a given site or once per sampling station per project, whichever is more frequent.	Metals and other common contaminants. [1]
ICS	Beginning and end of each analysis run or a minimum of twice per 8 hours.	Organics

Notes:
[1] Other common contaminants include organic carbon (TOC and DOC), and nitrate as N. Analyze blanks for these constituents as appropriate for constituents monitored in specific projects.
[2] A batch is defined as the group of bottles that have been cleaned at the same time, in the same manner; or, if decontaminated bottles were sent directly from the manufacturer, the batch would be the lot designated by the manufacturer in their testing of the bottles.

8.5 QA/QC Data Evaluation

All data reported by the analytical laboratory must be carefully reviewed to determine whether the project's data quality acceptability limits or objectives (DQOs) have been met. The data review methods should be outlined in the SAP developed for the project. A detailed discussion of the QA/QC data evaluation process for Caltrans storm water monitoring programs is presented in Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition). This process includes two steps; initial data quality screening and data quality evaluation.

Data quality screening includes the following steps:

1. Verification check between sampling and analysis plan (SAP), chain of custody forms, and laboratory data reports.

2. Check of laboratory data report completeness.

3. Check for typographical errors and apparent incongruities.

See the Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition) for details concerning the above.

The data quality evaluation process for particle data is similar to the process developed for water chemistry. Data evaluation as it relates to particle testing includes review of the following QA/QC parameters:

- Reporting limits
- Holding times
- Contamination check results (method, field, and equipment blanks)
- Precision analysis results (laboratory, field, and matrix spike duplicates)
- Accuracy analysis results (matrix spikes, surrogate spikes, laboratory control samples, and external reference standards)

Each of these QA/QC parameters should be compared to data quality acceptability criteria, also known as the project's data quality objectives (DQOs). The key steps that should be adhered to in the analyses of each of these QA/QC parameters are:

1. Compile a complete set of the QA/QC results for the parameter being analyzed.
2. Compare the laboratory QA/QC results to accepted criteria (DQOs).
3. Compile any out-of-range values and report them to the laboratory for verification.
4. Prepare a report that tabulates the success rate for each QA/QC parameter analyzed.

This process should be applied to each of the QA/QC parameters as discussed below.

8.5.1 Reporting Limits

DQOs established for all particle monitoring programs should contain a list of acceptable reporting limits that the lab is contractually obligated to adhere to, except in special cases of insufficient sample volume or matrix interference problems. The reporting limits should be selected to achieve a high probability of detection. Table 4-2 provides recommended reporting limits for selected parameters.

8.5.2 Holding Times

Holding time represents the elapsed time between sample collection time and sample analysis time. Calculate the elapsed time between the sampling time and start of analysis, and compare this to the required holding time.

It is important to review sample holding times to demonstrate the analyses occurred within the time period that is generally accepted to maintain stable parameter concentrations. Table 9-1 contains the holding times for selected parameters. If holding times are exceeded, inaccurate concentrations or false negative results may be reported. Samples that exceed their holding time prior to analysis are qualified as "estimated", or may be rejected depending on the circumstances.

8.5.3 Contamination

Blank samples are used to identify the presence and potential source of sample contamination and are typically one of four types:

- Method blanks are prepared and analyzed by the laboratory to identify laboratory contamination.
- Field blanks are prepared by the field crew during sampling events and submitted to the laboratory to identify contamination occurring during the collection or the transport of environmental samples.
- Equipment blanks are prepared by the field crew or laboratory prior to the monitoring season and used to identify contamination coming from sampling equipment (tubing, pumps, bailers, etc.).

If no contamination is present, all blanks should be reported as "not detected" or "non-detect" (e.g., constituent concentrations should not be detected above the reporting limit). Blanks reporting detected concentrations ("hits") should be noted in the written QA/QC data summary prepared by the data reviewer. In the case that the laboratory reports hits on method blanks, a detailed review of raw laboratory data and procedures should be requested from the laboratory to identify any data reporting errors or contamination sources. When other types of blanks are reported above the reporting limit, a similar review should be requested along with a complete review of field procedures and sample handling. Often times it will also be necessary to refer to historical equipment blank results, corresponding method blank results, and field notes to identify contamination sources. This is a corrective step that should be performed and documented as soon as the hits are reported.

If the blank concentration exceeds the laboratory reporting limit, values reported for each associated environmental sample must be evaluated according to USEPA guidelines for data evaluations of organics and metals (USEPA, 1991; USEPA, 1995) as indicated in Table 8-2.

Table 8-2
USEPA Guidelines for Data Evaluation

Step	Environmental Sample	Phthalates and other common contaminants	Other Organics	Metals
1.	Sample > 10X blank concentration	No action	No action	No action
2.	Sample < 10X blank concentration	Report associated environmental results as "non-detect" at the reported environmental concentration.	No action	Results considered an "upper limit" of the true concentration (note contamination in data quality evaluation narrative).
3.	Sample < 5X blank concentration	Report associated environmental results as "non-detect" at the reported environmental concentration.	Report associated environmental results as "non-detect" at the reported environmental concentration.	Report associated environmental results as "non-detect" at the reported environmental concentration.

8.5.4 Precision

Duplicate samples provide a measure of the data precision (reproducibility) attributable to sampling and analytical procedures. Precision can be calculated as the relative percent difference (RPD) in the following manner:

$$RPD_i = \frac{2 * |O_i - D_i|}{(O_i + D_i)} * 100\%$$

where:

RPDi = Relative percent difference for compound i

Oi = Value of compound i in original sample

Di = Value of compound i in duplicate sample

The resultant RPDs should be compared to the laboratory-developed data for RPD obtained from samples of similar matrix and criteria specified in the project's DQOs. Typical acceptance limits for precision are shown on Table 8-3. The criteria shown in Table 8-3 are based on the analytical method specifications and laboratory-supplied values. Project-specific DQOs should be developed with consideration to the analytical laboratory, the analytical method specifications, and the project objective. Table 8-3 should be used as a reference point as the least stringent set of DQO criteria for Caltrans monitoring projects.

Table 8-3
Typical Control Limits for Precision and Accuracy for Analytes in Sediments

Analyte	EPA Method Number [a]	Maximum Allowable RPD	Lower Recovery Limit	Upper Recovery Limit
Conventionals				
pH	9045C	35%	NA	NA
Eh	D-1498 [b]	35%	NA	NA
Total Organic Carbon (TOC)	9060	35%	65%	135%
Nutrients				
Total Kjeldahl Nitrogen (TKN)	5050/9056	35%	65%	135%
Nitrate (NO3)	5050/9056	35%	65%	135%
Nitrite (NO2)	5050/9056	35%	65%	135%
Total Phosphorus (P)	5050/9056	35%	65%	135%
Metals (total)				
Arsenic (As)	3050A/6010B	35%	65%	135%
Cadmium (Cd)	3050A/6010B	35%	65%	135%
Chromium (Cr)	3050A/6010B	35%	65%	135%
Copper (Cu)	3050A/6010B	35%	65%	135%
Lead (Pb)	3050A/6010B	35%	65%	135%
Nickel (Ni)	3050A/6010B	35%	65%	135%
Zinc (Zn)	3050A/6010B	35%	65%	135%
Iron (Fe)	3050A/6010B	35%	65%	135%
Metals (TCLP)				
Silver (Ag)	1311/6010B	35%	65%	135%
Arsenic (As)	1311/6010B	35%	65%	135%
Barium (Ba)	1311/6010B	35%	65%	135%
Cadmium (Cd)	1311/6010B	35%	65%	135%
Chromium (Cr)	1311/6010B	35%	65%	135%
Lead (Pb)	1311/6010B	35%	65%	135%
Selenium (Se)	1311/6010B	35%	65%	135%
Mercury (Hg)	1311/7061	35%	65%	135%
Metals (STLC)				
Silver (Ag)	CAM WET/6010B	35%	65%	135%
Arsenic (As)	CAM WET/6010B	35%	65%	135%
Barium (Ba)	CAM WET/6010B	35%	65%	135%
Beryllium (Be)	CAM WET/6010B	35%	65%	135%
Cadmium (Cd)	CAM WET/6010B	35%	65%	135%
Cobalt (Co)	CAM WET/6010B	35%	65%	135%
Copper (Cu)	CAM WET/6010B	35%	65%	135%
Chromium (Cr)	CAM WET/6010B	35%	65%	135%
Molybdenum (Mo)	CAM WET/6010B	35%	65%	135%
Nickel (Ni)	CAM WET/6010B	35%	65%	135%
Lead (Pb)	CAM WET/6010B	35%	65%	135%
Antimony (Sb)	CAM WET/6010B	35%	65%	135%
Selenium (Se)	CAM WET/6010B	35%	65%	135%
Thallium (Tl)	CAM WET/6010B	35%	65%	135%
Vanadium (V)	CAM WET/6010B	35%	65%	135%
Zinc (Zn)	CAM WET/6010B	35%	65%	135%
Mercury (Hg)	CAM WET/7061	35%	65%	135%
Amount or Weight				
Dry Weight	-- [c]	NA	NA	NA
Wet Weight	-- [d]	NA	NA	NA

Analyte	EPA Method Number [a]	Maximum Allowable RPD	Lower Recovery Limit	Upper Recovery Limit
Size Fraction				
Particle Size Distribution	D-1498/D-422 [b]	NA	NA	NA
Hydrocarbons				
TPG (gasoline)	8015M	35%	65%	135%
TPD (diesel)	8015M	35%	65%	135%
TPJ (jet fuel)	8015M	35%	65%	135%
TPK (kerosene)	8015M	35%	65%	135%
TPS (stoddard solvent)	8015M	35%	65%	135%
VOCs				
Benzene	8021	35%	65%	135%
Toluene	8021	35%	65%	135%
Ethylbenzene	8021	35%	65%	135%
Xylene	8021	35%	65%	135%

Notes:
[a] EPA SW-846 methods unless otherwise indicated. Equivalent Standard Method or EPA Method can be substituted.
[b] American Society for Testing and Materials (ASTM) Method.
[c] Dry in oven at 50C until constant weight. Record weight using an analytical balance.
[d] Do not dry. Record weight using an analytical balance.

8.5.5 Laboratory and Field Duplicates

The RPDs resulting from analysis of both laboratory and field duplicates should be reviewed during data evaluation. Deviations from the specified limits, and the effect on reported data, should be noted and commented upon by the data reviewer. Laboratories typically have their own set of maximum allowable RPDs for laboratory duplicates based on their analytical history. In most cases these values are more stringent than those listed in Table 8-3. Note that the laboratory will only apply these maximum allowable RPDs to laboratory duplicates. In most cases field duplicates are submitted "blind" (with pseudonyms) to the laboratory.

Environmental samples associated with laboratory duplicate results greater than the maximum allowable RPD (when the numerical difference is greater than the reporting limit) are qualified as "J" (estimated). When the numerical difference is less than the RL, no qualification is necessary. Field duplicate RPDs are compared against the maximum allowable RPDs used for laboratory duplicates to identify any pattern of problems with reproducibility of results. Any significant pattern of RPD exceedances for field duplicates should be noted in the data report narrative.

Corrective action should be taken to address field or laboratory procedures that are introducing the imprecision of results. The data reviewer can apply "J" (estimated) qualifiers to any data points if there is clear evidence of a field or laboratory bias issue that is not related to contamination. Qualification based on contamination is assessed with blank samples.

Laboratories should provide justification for any laboratory duplicate samples with RPDs greater than the maximum allowable value. In some cases, the laboratory will track and document such exceedances. However, in most cases it is the job of the data

reviewer to locate these out-of-range RPDs. Irregularities should be included in the data reviewer's summary, and the laboratory's response should be retained to document laboratory performance, and to track potential chronic problems with laboratory analysis and reporting.

8.5.6 Accuracy

Accuracy is defined as the degree of agreement of a measurement to an accepted reference or true value. Accuracy is measured as the percent recovery (%R) of spike compound(s). Percent recovery of spikes is calculated in the following manner:

$$\%R = 100\% * [(Cs - C) / S]$$

where:

%R = percent recovery

Cs = spiked sample concentration

C = sample concentration for spiked matrices

S = concentration equivalent of spike added

Accuracy (%R) criteria for spike recoveries should be compared with the limits specified in the project DQOs. Acceptance limits for percent recoveries are established by the environmental laboratory per EPA SW-846 protocols. Laboratory-specific quality control acceptance limits are established on a parameter-specific basis for each analysis method after sufficient data have been compiled. A list of typical acceptable recoveries is shown in Table 8-3. A value of 20 percent can be used for volume and density measurements. As in the case of maximum allowable RPDs, laboratories develop acceptable criteria for an allowable range of recovery percentages that may differ from the values listed in Table 8-3.

Percent recoveries should be reviewed during data evaluation, and deviations from the specified limits should be noted in the data reviewer's summary. Justification for out of range recoveries should be provided by the laboratory along with the laboratory reports, or in response to the data reviewer's summary.

8.5.7 Laboratory Matrix Spike, Matrix Spike Duplicate, and Surrogate Spike Samples

Evaluation of analytical accuracy and precision in environmental sample matrices is obtained through the analysis of laboratory matrix spike (MS) and matrix spike duplicate (MSD) samples. A matrix spike is an environmental sample that is spiked with a known amount of the constituent being analyzed. A percent recovery can be calculated from the results of the spike analysis. A MSD is a duplicate of this analysis that is performed as a check on matrix recovery precision. MS and MSD results are used together to calculate RPD as with the duplicate samples. When MS/MSD results

(%R and RPD) are outside the project specifications, as listed in Table 8-3, the associated environmental samples are qualified as "estimates due to matrix interference." Surrogate standards are added to all environmental and quality control samples tested by gas chromatography (GC) or gas chromatography-mass spectroscopy (GC-MS). Surrogates are non-target compounds that are analytically similar to the analytes of interest. The surrogate compounds are spiked into the sample prior to the extraction or analysis. Surrogate recoveries are evaluated with respect to the laboratory acceptance criteria to provide information on the extraction efficiency of every sample.

8.5.8 External Reference Standards

External reference standards (ERS) are artificial certified standards prepared by an external agency and added to a batch of samples. ERSs are not required for every batch of samples, and are often only run quarterly by laboratories. Some laboratories use ERS's in place of laboratory control spikes with every batch of samples. ERS results are assessed the same as laboratory control spikes for qualification purposes (see below). The external reference standards are evaluated in terms of accuracy, expressed as the percent recovery (comparison of the laboratory results with the certified concentrations). The laboratory should report all out-of-range values along with the environmental sample results. ERS values are qualified as "biased high" when the ERS recovery exceeds the acceptable recovery range and "biased low" when the ERS recovery is smaller than the recovery range.

8.5.9 Laboratory Control Samples

LCS analysis is another batch check of recovery of a known standard solution that is used to assess the accuracy of the entire recovery process. LCSs are much like ERSs except that a certified standard is not necessarily used with LCSs, and the laboratory prepares the sample internally so the cost associated with preparing a LCS sample is much lower than the cost of ERS preparation. LCSs are reviewed for percent recovery within control limits provided by the laboratory. LCS out-of-range values are treated in the same manner as ERS out-of-range values. Because LCS and ERS analysis both check the entire recovery process, any irregularity in these results supersedes other accuracy-related qualification. Data are rejected due to low LCS recoveries when the associated environmental result is below the reporting limit.

Section 9
Laboratory Sample Preparation and Analytical Methods

When using analytical laboratories, the following elements provide insight to maximize the data achieving DQOs.

- Laboratory Selection and Contracting
- Pre-Sampling Preparations
- Sample Storage and Handling Prior to Analysis
- Reporting Limit Requirements
- Analytical Methods
- Laboratory Data Package Deliverables

As with the elements listed in Sections 6 and 7, these laboratory elements need to be considered and incorporated into the project-specific SAP.

9.1 Laboratory Selection and Contracting

Important considerations in selecting a laboratory include performance, ability to meet test acceptability criteria, and experience with the types of particle testing included in the study. The laboratory should have a proven record of performance with the sample matrices involved in the study and the particular types of particle tests to be conducted for the project. Additionally, Department of Health Services (DHS) certification is required for Caltrans analytical work involving chemical content. DHS does not have certification for the other types of sediment analyses for grain size, weight, and mineral content.

It is important to establish that the selected laboratory has proven satisfactory performance. The ability of the laboratory to obtain consistent, precise results must be demonstrated. Data from laboratory controls must be checked to establish that the laboratory can consistently meet the test acceptability criteria established for controls.

Finally, it is necessary that laboratories be made contractually accountable to meet all Caltrans' data quality acceptability limits or objectives (DQOs) and project specifications. This is discussed in more detail later in this section.

9.2 Pre-Sampling Preparations

The analytical laboratories will be involved in a number of activities prior to the actual analysis of the particle and sediment samples, including:

- Determining key laboratory performance requirements (e.g., maximum reporting limits, turnaround times, report formats) for the services contract.
- Reviewing and commenting on DQOs, QC sample schedule, and QC sample volumes. This overall package is sometimes referred to as the QA/QC plan.
- Providing clean sample containers and blank water/sediment.
- Coordinating with sampling team prior to each anticipated sampling event.

Determination of Laboratory Performance Criteria. The analytical laboratory must analyze the water and sediment samples using methods that will achieve Caltrans' DQOs for the project (see Section 2). The contract for analytical services should specify laboratory performance criteria designed to meet the project DQOs. The contract should specify the following:

- Analytical reporting limits
- Holding times
- Types and frequency of QA/QC analyses
- Quality control performance limits
- Sample turnaround times
- Electronic and hard copy report formats
- Corrective action procedures

In addition, the contract with the laboratory should specify that at least 90% of the sample results must meet the QA/QC criteria and be deemed usable for the project.

Laboratory Input to Project QA/QC Plan. The contracted analytical laboratories should review and provide input to the QA/QC plan for each Caltrans storm water-related monitoring project including particle monitoring. This input will help prove that the QA/QC plan specifies the correct sample containers, sample volumes or amounts, holding times, analytical methods, reporting limits, and the correct points of contact for communications between field and laboratory personnel. In addition, the laboratories should be involved early in the process so they can provide feedback on methods and performance standards during the planning phase.

Sample Containers and Blank Water/Sediment. Each analytical method has specific requirements with regard to the type of sample container (e.g., plastic, glass, Teflon, amber glass), the size of the container, and the number of containers. Table 9-1 shows the appropriate sample containers for the analytical methods recommended for Caltrans monitoring programs. As noted above, the analytical laboratories should review the QA/QC plan for each Caltrans storm water project with particle

monitoring to confirm the plan specifies the appropriate sample containers, volumes, and preservatives.

As discussed in Sections 6 and 7, sampling personnel will need to request the appropriate containers from the laboratory prior to each sampling event. The containers needed for a given project will vary depending on the constituents to be analyzed, the sample collection procedure, and the DQOs. For example, storm water monitoring programs often include composite samples, wherein subsamples collected during a storm event may be combined in one or more large containers. After the composite sample has been delivered to the laboratory, the water or sediment is transferred from the composite sample containers into the individual containers required for each analysis, and the individual samples are then filtered and/or preserved as required. For monitoring projects that specify collection of grab samples, field personnel must obtain the appropriate clean bottles from the laboratory prior to the sampling event.

Sample volumes or amounts necessary for the requested analyses should be confirmed with the laboratory prior to sample collection, including sufficient sample volumes or amounts for the required laboratory QA/QC analysis. As discussed in Section 8, laboratory quality control samples that make use of sample water or sediments provided by the field crew include splits (laboratory duplicates), matrix spikes, and matrix spike duplicates. Additional sample volume or amount will also be required for field duplicate quality control samples, as discussed in Section 8.

If field blanks are to be collected, the laboratory also will need to provide sufficient quantities of blank water and sediment, and appropriate containers (see Section 8). The blank water supplied by the laboratory should be the same as the water used for equipment cleaning.

Laboratory Coordination Prior to a Sampling Event. It is important for the task manager to notify the laboratories of an anticipated sampling event so that the laboratory can prepare for sample delivery, and to set up for any analyses with short holding times. The laboratory contacts should be notified regarding the number of samples anticipated, approximate date and time of sampling (if known), and when sample containers, blank water or sediment, or ice chests will be required. In addition, the laboratories should be made aware of specific project requirements such as required laboratory performance objectives, required QC samples, and reporting requirements.

Table 9-1
Analytical Constituent Method Specifications and Recommended Reporting Limits

Analyte	Method Type	EPA Method Number [a]	Holding Time [b]	Container Type	Preservation	Reporting Limit (RL)	Units
Conventionals							
Total Suspended Solids (TSS)	Dried filtrate weight	160.1	7 days	Glass or PE [e]	4°C	1	mg/L
Total Dissolved Solids (TDS)	Dried filtrate weight	160.2	7 days	Glass or PE [e]	4°C	1	mg/L
Turbidity	Nephelometric	180.1	48 hours	Glass or PE [e]	4°C	0.05	NTU
Total Organic Carbon (TOC)	Oxidation	9060	28 days	Glass	4°C	50	mg/kg
pH	Slurry; Electrometric	9045C	ASAP	Glass or PE [e]	4°C	+/- 0.1	SU
Electrical Conductivity	Slurry; Electrometric	D-1498 [c]	ASAP	Glass or PE [e]	4°C	+/- 10	Semens
Nutrients							
Total Kjeldahl Nitrogen (TKN)	Digestion/Spectrometric	EPA Method 351.3M	48 hours	Glass or PE [e]	4°C	20	mg/kg
Nitrate (NO3) as N	Combustion/Ion Chromatography	5050/9056 [h]	48 hours	Glass or PE [e]	4°C	1	mg/kg
Nitrite (NO2) as N	Combustion/Ion Chromatography	5050/9056 [i]	48 hours	Glass or PE [e]	4°C	1	mg/kg
Total Phosphorous (P)	Combustion/Ion Chromatography	5050/9056 [j]	28 days	Glass or PE [e]	4°C	1	mg/kg
Metals (total)							
Arsenic (As)	Digestion/Spectrometric	3050A/6010B	180 days	Glass or PE [e]	4°C	1	mg/kg
Cadmium (Cd)	Digestion/Spectrometric	3050A/6010B	180 days	Glass or PE [e]	4°C	2	mg/kg
Chromium (Cr)	Digestion/Spectrometric	3050A/6010B	180 days	Glass or PE [e]	4°C	5	mg/kg
Copper (Cu)	Digestion/Spectrometric	3050A/6010B	180 days	Glass or PE [e]	4°C	2	mg/kg
Iron (Fe)	Digestion/Spectrometric	3050A/6010B	180 days	Glass or PE [e]	4°C	5	mg/kg
Lead (Pb)	Digestion/Spectrometric	3050A/6010B	180 days	Glass or PE [e]	4°C	5	mg/kg
Nickel (Ni)	Digestion/Spectrometric	3050A/6010B	180 days	Glass or PE [e]	4°C	5	mg/kg
Zinc (Zn)	Digestion/Spectrometric	3050A/6010B	180 days	Glass or PE [e]	4°C	2	mg/kg
Metals (TCLP)							
Arsenic (As)	Extraction; Spectrometric	1311/6010B	180 days	Glass or PE [e]	4°C	0.5	mg/L
Barium (Ba)	Extraction; Spectrometric	1311/6010B	180 days	Glass or PE [e]	4°C	5	mg/L
Cadmium (Cd)	Extraction; Spectrometric	1311/6010B	180 days	Glass or PE [e]	4°C	0.1	mg/L
Chromium (Cr)	Extraction; Spectrometric	1311/6010B	180 days	Glass or PE [e]	4°C	0.5	mg/L
Lead (Pb)	Extraction; Spectrometric	1311/6010B	180 days	Glass or PE [e]	4°C	0.5	mg/L
Mercury (Hg)	Extraction; Spectrometric	1311/7061	28 days	Glass or PE [e]	4°C	0.01	mg/L
Selenium (Se)	Extraction; Spectrometric	1311/6010B	180 days	Glass or PE [e]	4°C	0.1	mg/L
Silver (Ag)	Extraction; Spectrometric	1311/6010B	180 days	Glass or PE [e]	4°C	0.5	mg/L

Table 9-1 (continued)
Analytical Constituent Method Specifications and Recommended Reporting Limits

Analyte	Method Type	EPA Method Number [a]	Holding Time [b]	Container Type	Preservation	Reporting Limit (RL)	Units
Metals (STLC)							
Antimony (Sb)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	1	mg/L
Arsenic (As)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	0.5	mg/L
Barium (Ba)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	5	mg/L
Beryllium (Be)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	0.1	mg/L
Cadmium (Cd)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	0.1	mg/L
Chromium (Cr)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	0.5	mg/L
Cobalt (Co)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	0.5	mg/L
Copper (Cu)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	0.1	mg/L
Mercury (Hg)	Extraction; Spectrometric	CAM WET/7061	28 days	Glass or PE [e]	4°C	0.01	mg/L
Molybdenum (Mo)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	10	mg/L
Nickel (Ni)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	1	mg/L
Lead (Pb)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	0.5	mg/L
Selenium (Se)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	0.1	mg/L
Silver (Ag)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	0.5	mg/L
Thallium (Tl)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	0.5	mg/L
Vanadium (V)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	1	mg/L
Zinc (Zn)	Extraction; Spectrometric	CAM WET/6010B	180 days	Glass or PE [e]	4°C	2	mg/L
Hydrocarbons							
TPH-G (gasoline)	GC-FID	8015M	14 days	Glass [d]	4°C	1	mg/kg
TPH-D (diesel)	GC-FID	8015M	14 days	Glass [d]	4°C	50	mg/kg
TPH-J (jet fuel)	GC-FID	8015M	14 days	Glass [d]	4°C	50	mg/kg
TPH-K (kerosene)	GC-FID	8015M	14 days	Glass [d]	4°C	50	mg/kg
TPH-S (stoddard solvent)	GC-FID	8015M	14 days	Glass [d]	4°C	50	mg/kg

Table 9-1 (continued)
Analytical Constituent Method Specifications and Recommended Reporting Limits

Analyte	Method Type	Method Number [a]	Holding Time [b]	Container Type	Preservation	Reporting Limit (RL)	Units
VOCs							
Benzene	GC-PID/ECD	8021	14 days	Glass [d]	4°C	5	mg/kg
Toluene	GC-PID/ECD	8021	14 days	Glass [d]	4°C	5	mg/kg
Ethylbenzene	GC-PID/ECD	8021	14 days	Glass [d]	4°C	5	mg/kg
Xylene	GC-PID/ECD	8021	14 days	Glass [d]	4°C	15	mg/kg
Amount/Weight							
Dry Weight	Gravimetric	-- [f]	NA	Glass or PE [e]	None	0.1	g
Wet Weight	Gravimetric	-- [g]	14 days	Glass or PE [e]	None	0.1	g
Size Fraction							
Particle Size Distribution	Sieve/Hydrometer	D-1498/D-422 [c]	180 days	Glass or PE [e]	None	0.1	Fraction
Particle Counting	Electrical Property	Electrozone Sensing	180 days	Glass or PE [e]	None	0.1	Fraction
Particle Counting	Light Interaction	Laser Diffraction	180 days	Glass or PE [e]	None	0.1	Fraction
Particle Counting	Microscopic	Scanning Electron	180 days	Glass or PE [e]	None	0.1	Fraction
Mineral Content							
Mineral Identification	X-ray Diffraction		180 days	Glass or PE [e]	None	0.1	Fraction
Mineral Identification	Optical Microscopy		180 days	Glass or PE [e]	None	0.1	Fraction
Mineral Identification	Electron Microprobe		180 days	Glass or PE [e]	None	0.1	Fraction

Notes
[a] EPA SW-846 methods unless otherwise indicated. Equivalent Standard Method or EPA Method can be substituted.
[b] Holding time specified in EPA guidance or referenced in Standard Method for equivalent method.
[c] American Society for Testing and Materials (ASTM) Method.
[d] VOA bottle preferred.
[e] Can substitute any other appropriate containers, as necessary, to accommodate required sample size.
[f] Dry in oven at 50C until constant weight. Record weight using an analytical balance.
[g] Do not dry. Record weight using an analytical balance.
[h] Can substitute EPA Method 353.3M.
[i] Can substitute EPA Method 354.1M.
[j] Can substitute EPA Method 365.3M.

9.3 Sample Storage and Handling Prior to Analysis

To minimize the chance of sample contamination and unreliable analytical results, special measures must be taken during the storage and handling of samples prior to analysis. For example, samples must be collected and stored in the appropriate containers and preserved. In addition, some analytical methods require filtration of the sample prior to analysis. Finally, samples must be analyzed within established holding times. Several of these measures are discussed in more detail below.

Sample Filtration. To separate particles from the storm water, water samples must be filtered. Samples should be filtered in the laboratory as required for specific particle-related tests such as TSS, grain size, and sediment quality.

Holding Times. Table 9-1 lists the maximum acceptable analytical holding times for a comprehensive list of constituents potentially monitored in Caltrans projects. Holding times may be a factor affecting allowable sampling times if the laboratory has not agreed to work evenings or weekends.

To minimize the risk of exceeding the holding times, samples must be transferred to the analytical laboratory as soon as possible after sampling is complete. Moreover, the laboratory should be notified before the sampling begins so that it can prepare to analyze the samples immediately upon receipt.

When the holding times are relatively short (e.g., 48 hours and less), the time required to deliver the samples to the laboratory may be critical. Direct delivery by the field teams, overnight shipping, or courier can all provide reliable delivery services that will meet the required holding times. Very few particle-related parameters have short holding times as shown in Table 9-1.

9.4 Reporting Limit Requirements

Table 9-1 lists the reporting limits (RLs) for the comprehensive list of analytical constituents potentially monitored in Caltrans projects. The reporting limit is the minimum concentration at which the analytical laboratory can reliably report detectable values. This operational definition does not distinguish between the type of reporting limit, but relies on the laboratory's historical practice of reporting and a thorough review of laboratory practice and performance. The reporting limits in Table 9-1 are provided as a guide for monitoring projects that do not have historical data sets for reference.

It is important that the RLs derived for the project are low enough to provide useful results. For example, if the analytical results are to be compared with quality objectives every effort should be made that the RLs are lower. Therefore, the selected analytical methods should provide RLs at or below the criteria against which the results are to be compared.

RLs are often specific to a given type of sample matrix. The RL for a given sample may be elevated due to the presence of interfering compounds. For example, RLs for

metals in salt water are generally five to ten times higher than RLs for fresh water (when using the same method), due to salt interference with the atomic absorption instrument.

9.5 Analytical Methods

This section discusses the analytical methods that should be used to meet the reporting limits and other DQOs for the project (Section 2 describes how project DQOs are developed). As discussed in Section 4, analytical constituents are selected based on regulatory requirements, water quality objectives, historical data, and other considerations.

For some constituents, alternative analytical methodologies may be used to meet the data quality objectives for reporting limits and control limits of QC samples. Also, methods are being updated and new methods developed for different analytical parameters.

In selecting the analytical method to be used, the following questions should be addressed:

- Does the method conform to any regulatory requirements for the monitoring program?
- Does the method allow the required reporting limits to be easily obtained on storm water samples?
- Does the method have the same or more stringent control limits for QA/QC samples?
- Will the data provided by the method be comparable to historical data collected at the station?
- Is the method recognized as "standard" so that the data collected at a station can be compared to other stations?
- Is the laboratory proficient with the method? Do they have historical data to show proficiency?

The recommended analytical methods for conventional, nutrient, metal, and organic constituents are discussed below and are shown in Table 9-1. All of these methods are described in the listed EPA method. A complete list of the constituents in each EPA method is available on CD-ROM (Methods and Guidance for Analysis of Water – EPA 821-C-99-004). The 8000 series analyses (modified soils methods) can be downloaded from the Internet at "http://www.epa.gov/SW-846/8xxx.htm". The approved methods should be referenced for more detailed sampling and analytical information.

Conventional Parameters. Totals dissolved solids (also described as filterable residue), described in EPA Method 160.1, are measured by evaporating the filtrate from a previously filtered storm water sample and weighing the remaining solids. TSS is measured by filtering the storm water sample and recording the increase in filter weight, as described by EPA Method 160.2. The recommended RLs for these methods are listed in Table 9-1. Turbidity is a measure of how much light a storm water sample will scatter; highly turbid (cloudy) samples will scatter more light than clear samples. The measurement of turbidity is accomplished using EPA Method 180.1. Total organic carbon is the measure of all forms of carbonaceous material in a sample. Method 9060 converts the carbon into carbon dioxide. The amount of carbon dioxide produced is directly proportional the concentration of TOC.

Nutrients. Nitrite and nitrate are determined in sediment samples using EPA Methods 5050 (combustion) or 9056 (ion chromatography) and are expressed as the concentration of nitrogen. TKN is typically measured using EPA Method 351.3, in which ammonia is determined after distillation by titrimetric, colorimetric, or potentiometric procedures. Phosphorous (total) is also determined in sediment samples using EPA Methods 5050 (combustion) or 9056 (ion chromatography).

Metals. The methods are:

Metals (total) – Digestion of the sediment sample followed by inductively coupled plasma (ICP) spectrometric analysis of the digestate using methods 3050A and 6010B.

Metals (TCLP) – The TCLP method (1311/6010B) is designed to evaluate the potential of the sediment to generate hazardous leachate (especially after disposal in a Municipal landfill). Results correspond to concentrations in the leachate (mg/L).

Metals (STLC) – STLC is the California equivalent of the TCLP (method CAM WET/6010B). In the STLC, a different extraction fluid is used. Results correspond to concentrations in the leachate (mg/L).

Organics. EPA Method 8015 modified/extended is recommended for analysis of Caltrans' storm water samples, because it distinguishes between the types of hydrocarbons present in the sample, and there is no concern of non-petroleum interferences. EPA Method 8015 mod/ext. also provides additional confidence in sample results because of the additional quality control/quality assurance procedures included with the method. Caltrans should specify to the analytical laboratory that the samples should be analyzed by EPA Method 8015 mod/ext. and quantified for the hydrocarbon range(s) of interest. The laboratory should review the chromatograms to confirm that the summary report of analytical results actually represents hydrocarbons, which shows a gas chromatographic trace similar to hydrocarbon range(s) of interest. The gas chromatograms for the samples, quality control samples, and standards can be requested in the data package.

The recommended methods for analysis of solvent-related constituents in sediments are EPA Methods 8021.

Sediment Amount or Weight. The weight of filtrate or sediments samples will be performed using a calibrated scale (analytical balance) with a reporting limit of 0.1 grams. There are no standard methods other than proper analytical procedures for weighing materials, and there are no requirements for container types, preservatives, or holding times.

Grain Size Fraction. The following paragraphs describe individual methods that are applicable to particle size analysis of suspended sediments found in runoff. Selection of applicable methods was based on a number of criteria including sample size, commercial availability of the method, practicality of sample collection and preparation, and capability of analyzing the wide range of particle sizes in storm water runoff.

All particle size measurement methods are based on the assumption of equivalent diameter (i.e., Equivalent Sphere Theory), in that they attempt to measure some physical property (or other behavior or attribute) that can be related to the diameter (size) of an equivalent sphere.

Sieving and Screening. The oldest sorting and classification method is sieving and screening, in which particles are separated into various size fractions based on their ability to pass through a series of wire mesh sieves with square apertures of various standard sizes (i.e., the size determination is sieve diameter). The smallest sieve (#635) has an aperture size of 20 µm, so the method is not capable of separating very small particles. This method is capable of sizing particles ranging between about 20 – 127,000 µm. American Society for Testing and Materials (ASTM) Method D-1498 is recommended sieving and screening method.

Hydrometer. The hydrometer method is a gravitational, sedimentation-based method. This method is among the most commonly used technique for particle size and size distribution determination. The sedimentation method is based on the measure of the velocity with which a particle in a fluid settles due to the gravitational forces acting on the particle, against the buoyancy of the fluid and other drag forces acting against the settling of the particle. An attempt is made to measure the changes in the dispersion of the particles over time.

For the hydrometer method, the changes induced by settling are measured by differences in the density of the dispersion. A hydrometer is simply a vertical float, inscribed with a graduated scale, which sinks into the liquid dispersion until it has displaced a volume of liquid equal in weight to that of the float. As particles settle by gravity, the density of the liquid suspension decreases and the hydrometer readings change accordingly. The method is capable of quantification of grain sizes between 1 and 75 µm. American Society for Testing and Materials (ASTM) Method D-422 is recommended hydrometer method.

Sieving and hydrometer can be combined to measure a range of grain sizes between 1 and 127,000 µm. Both methods express the results in terms of percentage of total

weight. The results can be presented in both tabular and graphic format. Table 9-2 presents an example of tabular results and Figure 9-1 shows the results in a graphical format.

Table 9-2
Example of Tabular Results from Sieve / Hydrometer Tests

Grain size (µm)	Mass Finer (%)		
	Sample #1	Sample #2	Sample #3
12,700	100	100	100
9,530	96.54	100	100
4,750	95.58	99.44	99.94
2,000	91.07	96.03	99.74
850	77.22	87.06	98.76
425	52.03	76.13	96.49
250	31.75	65.95	92.98
150	20.25	56.07	87.65
75	11.60	41.10	71.16
38	7.22	21.90	43.67
20	5.91	15.00	29.62
18	4.30	12.89	26.26
9	1.75	7.00	20.14
5	1.00	5.50	12.57
2	0.63	3.25	7.79

One weakness of the sieve and hydrometer analyses is the amount of sample required to perform the analyses. For both analyses, 120 grams of dry sediment are required. This amount is typically not a problem to collect from sediment deposits. However, it can be a problem when deriving the sediment from relatively clean storm water runoff samples. To collect 120 grams of sediment from storm water, a large volume of storm water may need to be required depending on the total suspended solids (TSS) concentration. Assuming the storm water runoff has an average TSS concentration of 200 milligrams per liter (mg/L), approximately 600 liters (160 gallons) of water sample would be needed to collect 120 grams of dry sediment for this analysis. Table 9-3 summarizes other sample volumes required for different TSS concentrations.

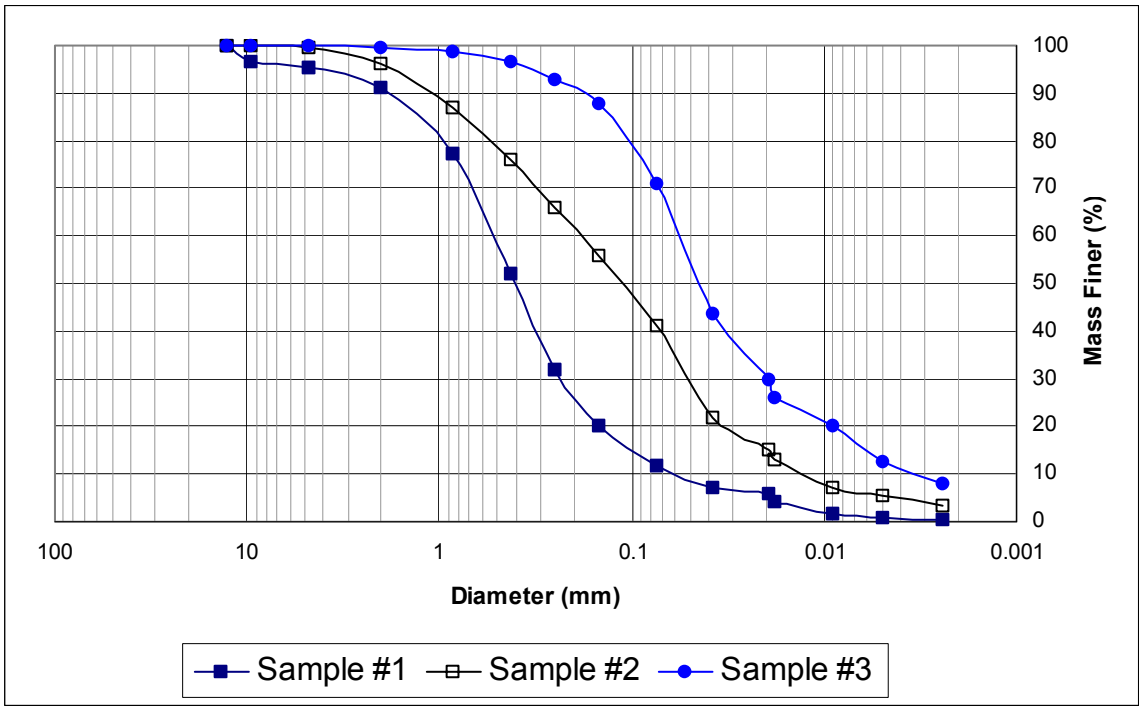


Figure 9-1
Example of Graphical Results from Sieve / Hydrometer Tests

Table 9-3
Example of Sample Volumes Required for Sieve Analysis

TSS Concentration in the Runoff Sample (mg/L)	Runoff Sample Volume Required (liters)
20	6,056
200	606
2,000	60

To overcome this sample amount/volume issue, three methods are available that count the number of particles and partition them in various grain size ranges. Considerably less sample size is required to perform the counting. Results are expressed in terms of percentage of the total number of particles counted. The three methods include electrozone, laser diffraction, and microscopic. They are each described below.

These three methods were selected based on their availability at commercial laboratories. There are no standard methods and there are no requirements for container types, preservatives, or holding times.

Electrozone Method. The electrozone method (based on the Coulter principle) measures the electrical current between two electrodes in the liquid on either side of a small aperture, in which a suspension of particles is forced to flow. As the particles

pass through the aperture, the impedance between the electrodes changes and produces an electrical pulse having a magnitude proportional to the particle volume. The pulses are electronically scaled, counted and accumulated in size related channels. These results produce a size distribution curve. Typical electrozone analyzers can count up to 2,000 particles per second.

Laser Diffraction. Laser diffraction instruments comprise a light source (typically a low power laser source), optical elements to process the incident beam, and a sample cell within which the sample is introduced (as a liquid suspension). Light scattered from the sample is then focused onto a detection system, which is usually a multielement array of numerous detectors placed at discrete locations. The detectors convert the scattered light intensity incident upon them into electrical signals that are then processed to obtain information about the particle size and size distribution.

Microscopic. All microscopic methods involve direct observation of particles and the consequent determination of size based on the diameter of a sphere that has the same projected area as the projected image of the particle. The calculated sizes or size distributions can then be converted to, or expressed in, volume or mass distributions with suitable assumptions (e.g., particle density).

When compared to other techniques of particle size analysis, a significant advantage of microscopic methods lies in the ability to determine the particle shape, in addition to making a direct measurement of size. Numerous commercial instruments and software packages are available for particle size and size distribution analysis. Instruments used for microscopic techniques include optical light microscopes, scanning electron microscopes (SEM), and transmission electron microscopes (TEM). The choice of the instrument to be used is determined by the size range of the particles being studied, magnification, and resolution that are desired. The SEM method (with automatic image analysis) seems the most applicable for sediments found in storm water runoff because of its resolution range of 0.1 – 1,000 mm.

Table 9-4 summarizes each method in terms of range of particle sizes, number of intervals, detection limit, sample volume, and cost.

Table 9-4
Summary of Particle Counting Methods

	SEM	Electrozone	Laser Diffraction
Grain Size Range	0.08 - 5 µm	0.4 - 200 µm	0.5 - 100 µm
No. of Grain Size Intervals	3 – 5	128	8 *
Detection Limit	1 / L	10 /L	1,000 - 10,000 / L
Sample Size	< 1 mL	10 – 200 mL	50 – 100 mL
Average Cost per Sample	$250	$ 110	$135

* Laser diffraction offers eight (8) standard intervals but an infinite number of intervals can be added at a cost of $75 per eight intervals.

To convert the particle numbers to mass, the average volume of each particle grain category or range must be calculated and a density estimated. The volume can be calculated by assuming each particle is spherical in shape with a diameter that represents the midpoint of the grain size range. The mineral content of the sample is used to estimate the average particle density.

Mineral Content. Three general methods commonly available for the mineralogic analysis of sediments include X-ray diffraction (XRD), optical microscopy, and electron microprobe. These methods are briefly described below.

X-ray Diffraction. XRD analysis is conducted with a powder diffractometer using Cu-Kα radiation. The sediment sample is ground to a powder and scanned over a range of angles. This results in a spectrum of diffraction angles where the angle of diffraction corresponds with a particular chrystalline mineral phase and the intensity of diffracted radiation corresponds with the concentration of the mineral phase. Nonchrystalline (amorphous) material is estimated based on the difference between 100 percent and the total mineral concentration. The average detection limit is approximately 1-3 percent for chrystalline mineral phases.

Optical Microscopy. Optical microscopic analysis can include four types: (1) stereo microscopic analysis of the whole sample, (2) reflected light analysis of a polished grain mount, (3) transmitted light analysis of a thin section, and (4) transmitted light analysis of an oil immersion mount. Optical microscopy using all four types allows general characterization of the chrystalline and nonchrystalline composition as well as identification and concentration of major mineral phases. This technique is highly dependent upon the skill and experience of the analyst. The average detection limit is approximately 1-5 percent for mineral phases.

Electron Microprobe. Electron microprobe analysis is conducted with a scanning electron microscope equipped with energy dispersive and/or wavelength dispersive X-ray fluorescence (XRF) spectrometers. A polished mount of the sample is first observed under the scanning electron microscope in backscatter electron mode in which the brightness of sediment grains are directly related to the average atomic number of the elements in each phase. The elemental composition of a selected grain is then determined by energy and/or wavelength dispersive XRF spectral analysis using a narrowly focused beam of electrons. The combination of backscatter scanning and electron microprobe analysis allows the analyst to provide both a general characterization of the sample (similar to optical microscopy) and to obtain detailed elemental compositions for selected mineral grains, which is particularly useful for identifying trace element impurities and geochemical associations. This technique is highly dependent upon the skill and experience of the analyst. The average detection limit is less than 1 percent but depends on the number of grains examined with the microprobe.

These three methods were selected based on their availability at commercial laboratories. There are no standard methods and there are no requirements for container types, preservatives, or holding times.

9.6 Laboratory Data Package Deliverables

As a part of the laboratory contract, the data package that will be delivered to Caltrans and the timing of its delivery (turn around time) should be defined. The data package should be delivered in hard copy and electronic copy (on diskette).

The hard copy data package should include a narrative that outlines any problems, corrections, anomalies, and conclusions, as well as completed chain of custody documentation. A summary of the QA/QC elements must be in the data package:

- Sample extract and analysis dates
- Results of method blanks
- Summary of analytical accuracy (matrix spike compound recoveries, blank spike compound recoveries, surrogate compound recoveries)
- Summary of analytical precision (comparison of laboratory split results and matrix spike duplicate results, expressed as relative percent difference)
- Reporting limits

In addition to the hard copy, an electronic copy of the data needs to be requested from the laboratory. The electronic copy includes all the information found in the hard copy data package. Data reporting and the standardized electronic format for Caltrans data submittals are discussed in Section 10.

Common turn around times for laboratory data packages are three weeks to thirty days for hard copy and electronic copy. The hard copy data package should undergo data review as described in Section 8.

Section 10
Data Reporting Protocols

All data collected as part of a Caltrans storm water monitoring project are entered into the Caltrans Statewide Stormwater Database. To facilitate data management, analysis, and the comparison of results from Caltrans Districts throughout the State, a uniform system for data reporting is required for all Caltrans monitoring projects, including particle studies. On an annual basis, Caltrans updates and distributes a Data Reporting Protocols document that describes the manner in which data should be entered into the Database. An upcoming version of the Data Reporting Protocols will include protocols for water quality data, toxicity data, and litter data in addition to particle data. The data reporting protocols specific to particle results are presented in this section, along with general instructions for all storm water data entered in the Caltrans Stormwater Database and the general organization of the database. These specific topics are covered in the following order:

- General Instructions
- Data Handling and Management
- Organization of the Caltrans Statewide Stormwater Database
- List of Important Fields for the Particle Portion of the Database

The entire document for particle data reporting protocols is presented in Caltrans Particle/Sediment Data Reporting Protocols (CTSW-RT-02-041).

10.1 General Instructions

Every monitoring site is assigned an ID number by Caltrans. At the beginning of each monitoring season, data reporters must contact the Caltrans database manager to receive the Site ID for each site to be sampled. Data reporters provide the name of the site, Caltrans District, and constituents to be monitored. The database manager then supplies the appropriate Site IDs, or assigns them, if previously unmonitored sites are added to a project.

Standardized entries are provided for almost every field. These entries must be used exactly as presented in the Protocols (including for example specifications for spacing, hyphenation or capitalization), and attention must be given to the units specified for each constituent. If the standardized list does not contain an appropriate descriptor, the data reporter should contact the database manager prior to submitting any non-standardized entries.

The database manager will provide every data reporter with a data-reporting worksheet (Excel file format) in which all data must be submitted. All data fields should be included, even when they are left blank. For detailed instructions on how to include time series data, see Caltrans Storm Water Monitoring Protocols (CTSW-RT-00-005, Second Edition). For the reporting of dates and times, specific formats and

references are dictated in the Protocols, as is a definition of a precipitation event. The purpose is to provide consistency in data reporting and calculation of summary statistics.

10.2 Data Handling and Management

Efficient data storage, retrieval, and transfer methods should be established prior to initiation of monitoring activities. The following suggestions are provided to guide in the development of a reliable and useful data management system:

- Establish a central file for hard copy information; create a system so that new information is not confused with current information.
- Select a database system that can accommodate digital information such as laboratory analyses and recorded data logger measurements.
- Choose a database program that allows for efficient data input, back up, and retrieval of selected information in response to queries.
- To perform useful queries, include the following categories in the same database: sampling event description, catchment area characteristics, sample identification information, sample collection and runoff data, analytical results, analytical methods, and data qualifiers.
- Coordinate electronic data transfer with the analytical laboratory (i.e., the laboratory should provide analytical results in an electronic format that can be directly input into the program's existing database). This can save time and minimize data entry errors.
- Apply Caltrans hydrologic tool to evaluate flow and rainfall data and to prepare storm-event hydrographs.
- Apply Caltrans data validation and checker tool to all analytical data received from the lab.

All storm water monitoring data will be incorporated into the Caltrans Statewide Storm Water Database. See Section 10.3 and Caltrans Particle/Sediment Data Reporting Protocols (CTSW-RT-02-041) for specific data reporting protocols.

10.3 Organization of the Caltrans Statewide Stormwater Database

As discussed in the introduction to this section, all data collected as part of a Caltrans storm water monitoring project are entered into the Caltrans Statewide Storm Water Database as the means to facilitate data management, analysis, and the comparison of results.

The database is separated into four data categories:

- Water quality
- Litter
- Toxicity
- Particle

Each category is further divided into the same four sections:

- Sample Description
- Sampling Event Description
- Site Descriptions
- Constituent List

The first three sections include numerous fields that provide information on the sites, events, and results. These three sections always contain an "Event ID" and "Monitoring Site ID" fields with each entry so the information can be easily cross-referenced. The fourth section, Constituent List, simply provides the possible constituents included in the field measurements and laboratory analyses from a given monitoring program.

The Sample Description portion of the database allows for input of standard information associated with samples. These data can be instrumental in interpreting results. The information included in this section of the database describes the sample itself: when and how it was collected, what it was analyzed for, the method and lab used to perform the analysis, and the result of the analysis. This section also allows the data reporter to characterize the sample source, as well as the portion of an event that is represented by the sample.

The second section of the database contains data that describes the precipitation event itself if relevant to the study. For particle monitoring, sampling may not be conducted during an event but rather during periods of dry weather. For a storm event, this section includes when the rain started and stopped, rainfall intensity, when runoff started and ended, the total amount of rainfall prior to, and during, the event, and antecedent dry days. For non-storm event monitoring, precipitation and runoff information is reported for the entire sampling period if measured and relevant, otherwise this section of the database is left blank.

In the third section of the database, the data reporter enters records that describe the site at which the sample was obtained. The fields include categories like geographic information and governing jurisdictions, such as latitude/longitude coordinates,

hydrologic sub-area, land use, size of the watershed, county, Caltrans District, and Regional Water Quality Control Board (RWQCB).

The final section lists the standard constituent names to be applied in the database for all Caltrans studies. The names may be full names or acronyms. The appropriate units are also listed.

10.4 List of Important Fields within the Particle/Sediment Database

This section lists the data fields in the Database specific to particle/sediment monitoring results. It is not meant to reproduce the Protocols, but simply to give the reader an idea of the type of information that is required from data reporters.

The "Sample Description" section for the particle portion of the database is similar to the "Sample Description" portion of the water quality database. One additional field has been added and other fields have been modified to include additional elements. Database fields specific to particle results include information such as particle size fraction, sample source, event representation, sample type, sample matrix, constituent type, units, preparation method, and method reference. The specific data fields included in the "Sample Description" section of the particle portion of the database are presented in the example spreadsheet included as Figure 10-1. Examples of data that may be entered into each of the data fields are also included in Figure 10-1. The various field and sub-fields are described in Caltrans Particle/Sediment Data Reporting Protocols (CTSW-RT-02-041).

The "Sampling Event" description section is identical to the water quality portion of the database which includes such fields as the Rain Start Time, Rain End Time, Rain Start Date, Rain End Date, Event Rain, Max Intensity, Total Flow Volume, Peak Flow and the Estimated % Capture, as well as who collected the sample. The various field and sub-fields are described in Caltrans Particle/Sediment Data Reporting Protocols (CTSW-RT-02-041).

The "Site Description" portion is also identical to the water quality database fields, which include the Caltrans District, County, RWQCB, Latitude, Longitude, Land Use, Catchment Area, Impervious Fraction, Post Mile, Receiving Water Type, Time Series, and Site Description. BMP Type and Receiving Water Type were modified to include elements unique to particle studies. The various field and sub-fields are described in Caltrans Particle/Sediment Data Reporting Protocol (CTSW-RT-02-041).

Site ID	Event ID	Sample Source	Event Representation	Sample Type	Sample Matrix	Constituent Type	Reported Value	Units	Preparation Method	Particle Size Fraction
3-202	2001-3	Sediment	Multiple	CW	Sediment	PS	23.4	%	Drying	
3-202	2001-3	Sediment	Multiple	CW	Sediment	*Cu*	35.6	mg/kg	Drying	60-75
3-202	2001-3	Storm	Discrete	G	Water	*GRAV*	0.8	mg	Drying	

Figure 10-1
Example of Specific Particle/Sediment Data Fields

Section 11
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ASTM B821-92 Standard Guide for Liquid Dispersion of Metal Powders and Related Compounds for Particle Size Analysis

ASTM B822-92 Standard Test Method for Particle Size Distribution of Metal Powders and Related Compounds by Light Scattering

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Section 12
Acronyms

ASTM	American Society of Testing Methods
BMP	best management practice
BS	blank split
COC	chain-of-custody
DHS	Department of Health Services
DI	deionized water
DQO	data quality objective
DQEP	data quality evaluation plan
EMC	event-mean concentration
EPA	Environmental Protection Agency
ERS	external reference standards
HSP	health and safety plan
ICP	inductively coupled plasma
ICS	interference check sample
LCS	laboratory control samples
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
ND	not detected
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
PQL	practical quantification limits
QA	quality assurance
QC	quality control
QPF	quantity of precipitation forecast
RPD	relative percent difference
RL	reporting limit
ROW	right-of-way
SAP	sampling and analysis plan
SEM	scanning electron microscope

SOP	standard operating procedure
STDS	Solids Transport and Deposition Study
STLC	State toxicity leaching characteristic
SWMP	Storm Water Management Program
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TEM	transmission electron microscope
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
XRF	X-ray fluorescence method

APPENDIX A

The *2003-2004 Particle/Sediment Data Reporting Protocols* can be found in the Data Reporting section of this manual.

SECTION 1.3

Caltrans Monitoring Protocols: Gross Solids Monitoring

GUIDANCE DOCUMENT

GUIDANCE FOR MONITORING STORM WATER GROSS SOLIDS

CTSW-RT-00-025

State of California - Business, Transportation and Housing Agency
Department of Transportation
Environmental Program (MS-27)
1120 "N" Street
Sacramento, CA 95814

October 2000

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B - Example Checklist for Pre-Storm Set Up of Litter Monitoring Sites
C - Example Checklist for Post-Storm Litter Monitoring
D - Example Checklist On-Site Monitoring Procedures
E - Sample Litter Chain of Custody Form
F - Caltrans Litter Laboratory Coordination and Sample Delivery Protocol
G - 2000-2001 Caltrans Litter Laboratory Analysis Method

SECTION 1 INTRODUCTION

The purpose of this document is to provide guidelines for planning, implementing and reporting storm water litter monitoring programs. This document is designed to supplement the Caltrans Guidance Manual: Stormwater Monitoring Protocols (Caltrans 2000a), referred to herein as "Caltrans Monitoring Protocols" and provides specific guidance for the unique requirements of monitoring litter as a storm water quality constituent. This document presents methods for litter monitoring and analysis based on first-hand experience collected to date from the Caltrans Litter Management Pilot Study (LMPS), conducted during the 1998-1999 and 1999-2000 rain seasons (Caltrans 2000b), as well as supplementary information from other sources.

The focus of this manual is on the litter component of a storm water quality monitoring plan. There have been numerous characterization studies of the chemical storm water quality constituents (such as TSS, nutrients, metals, oils and greases). However, there have been very few measurements reported of the amount and characteristics of litter in storm water. Our understanding of storm water litter, its sources, transport mechanisms, and ways to remove it is rudimentary.

These guidelines will be updated as Caltrans knowledge base regarding storm water litter monitoring grows. The objective of establishing this litter monitoring guidance is to provide a platform for the consistent use of litter monitoring and analysis methods so that data are comparable between locations and studies with the ultimate goal of reducing litter in Caltrans storm water runoff.

This document has been organized to parallel the Caltrans Monitoring Protocols and provides information to supplement relevant sections of that document to address litter monitoring in storm water. This document is therefore organized in two parts: Part I: Monitoring Plan Issues for Storm Water Litter and Part II: Implementing the Litter Monitoring Plan.

DEFINITION OF STORM WATER LITTER

Litter in storm water is defined by Caltrans as manufactured items made from paper, plastic, cardboard, glass, metal, etc. that can be retained by 5-mm (¼ inch) mesh. This definition does not include materials that are of natural origin (i.e. does not include sand, soil, gravel, vegetation, etc.). Storm water litter is quantified by 24-hour air-dried volume and weight.

STORM WATER GROSS POLLUTANTS

Gross pollutants collected in storm water litter monitoring devices consist of litter as well as a substantial portion of vegetation. In the Caltrans LMPS, the average percent vegetation by wet weight in storm event gross pollutants ranged from 75 to 87 for four areas on two Los Angeles freeways.

For the Caltrans LMPS, litter and vegetation pieces collected from the drainage system were small in size resulting from the sieving effect of the Caltrans standard parallel bar grate. The

Caltrans standard parallel bar inlet grate has 1-meter bars, with 35-mm (1½-inch) spacing and is effective in keeping large pieces of litter out of the drain inlets. The variable nature of storm water gross pollutants make them difficult to capture and sample. In addition, no techniques have been developed that can separate litter from vegetation in sampling systems. Therefore, when sampling for storm water litter, considerable amounts of vegetation will also be collected.

LITTER IMPACTS AND REGULATORY ISSUES

Storm water litter has become a substantial problem in California, as demonstrated by the listing of 36 California water bodies (19 as high priority) as impaired due to trash on the EPA 303(d) list. The impaired waterways are listed in Appendix A. Currently, the Los Angles Regional Water Quality Control Board (RWQCB) has drafted a trash Total Maximum Daily Load (TMDL) for the Los Angeles River, with a draft TMDL pending for the Ballona Creek, also in Los Angeles. The LA RWQCB has described water quality impacts of trash in the Draft LA River Trash TMDL as follows:

> *"Trash in rivers, streams and other waterways causes serious water quality problems, Small and large floatables can inhibit the growth of aquatic vegetation, decreasing spawning areas and habitats for fish and other living organisms. Wildlife living in rivers and in riparian areas can be harmed by ingesting or becoming entangled in floating trash. Settleables affect bottom feeders and contribute to sediment contamination. Some debris also convey nutrients, toxic substances, and other pollutants to the aquatic ecosystems. Floating debris that is not trapped and removed may eventually end up on the beaches or in coastal waters."*

CALTRANS STORM WATER LITTER CHARACTERISTICS

Caltrans has conducted one study to date that collected monitoring data related to storm water litter and gross pollutant characteristics. The Caltrans LMPS (Caltrans, 2000b) involved storm water litter monitoring as well as assessing the performance of a number of BMPs for litter reduction during two storm seasons in the Los Angeles area (1998-1999 and 1999-2000). It should be noted that monitoring for the LMPS was conducted on small (less than 0.4 hectare/one-acre) catchments on urban freeways in the Los Angeles area during rain seasons with less than average precipitation. Storm water litter characteristics may vary for other monitoring locations, time periods, and weather conditions. Main observations related to litter characteristics from the LMPS are:

- Between 75-87 percent of the gross pollutants by wet weight carried by storm water are vegetative material (such as leaves and twigs);
- Plastics, Styrofoam, and paper (including paper and cardboard) are the main components of storm water litter materials monitored (see Figures 1-1 and 1-2), with very high numbers of cigarette butts also found;

- Average annual litter loads monitored at drainage outfalls ranged from 3kg (18 L) to 8 kg (58 L) per acre of freeway surface, based on air-dried litter;
- Average annual gross pollutant loads monitored at drainage outfalls ranged from 58 kg to 115 kg per acre of freeway surface by wet weight;
- The moisture content of the litter was variable.
- Material was deposited into the drainage system via both dry and wet weather processes.

Figure 1-1
MATERIAL TYPES IN STORM WATER LITTER FROM TWO SEASONS OF MONITORING FOR THE CALTRANS LMPS (PERCENT COMPOSITION BY AIR-DRIED WEIGHT)

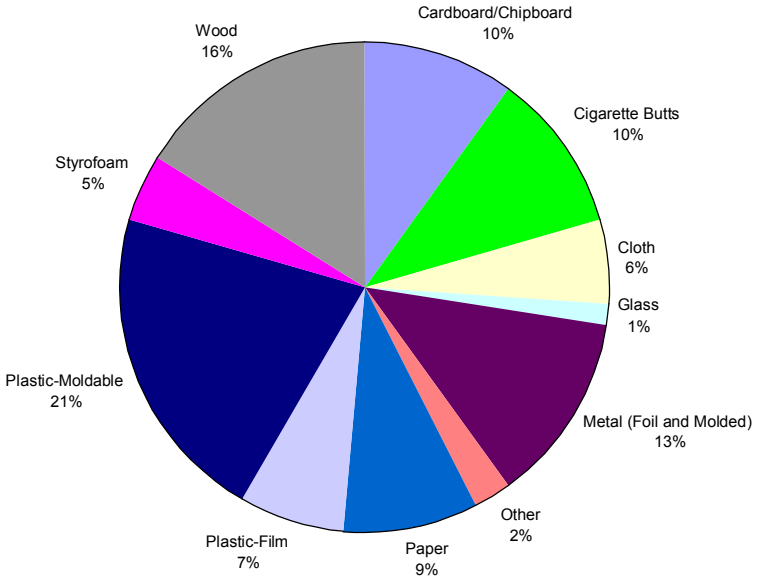
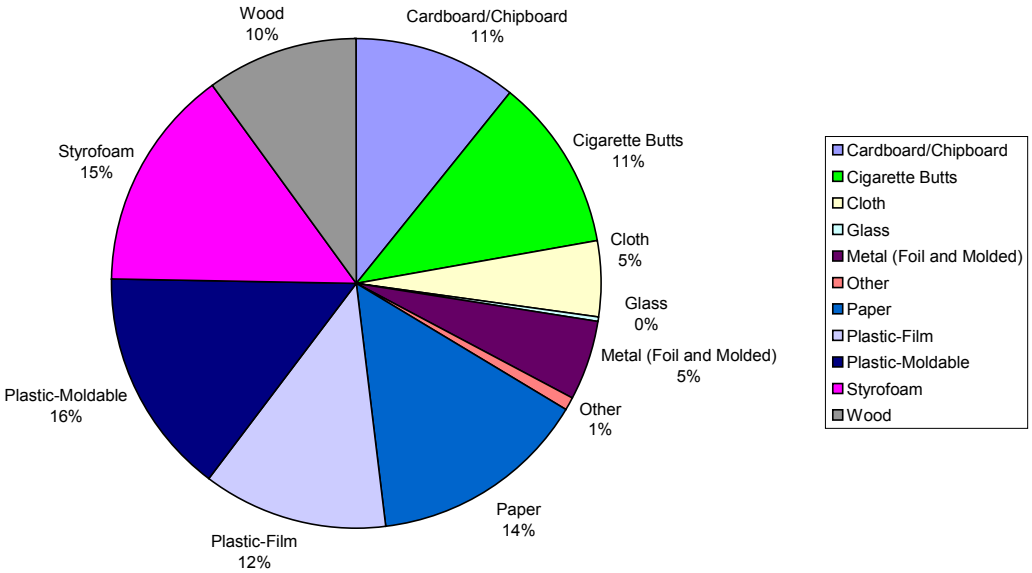


Figure 1-2
MATERIAL TYPES IN STORM WATER LITTER FROM TWO SEASONS OF MONITORING FOR THE CALTRANS LMPS (PERCENT COMPOSITION BY VOLUME)



PART I - MONITORING PLAN ISSUES FOR STORM WATER LITTER

Part I describes a process for developing a litter monitoring strategy to be incorporated with a project-specific monitoring plan. Topics addressed are:

- Section 2 – Purpose and Objectives of Monitoring
- Section 3 – Site Selection
- Section 4 – Constituent Selection
- Section 5 – Monitoring Methods and Equipment
- Section 6 – Sampling and Analysis Plan

SECTION 2 DEVELOP PURPOSE AND OBJECTIVES FOR LITTER MONITORING

Identifying the purpose and objectives related to litter monitoring for a specific project involves the same seven steps that are essential to determining objectives for an overall storm water monitoring plan. The seven steps are:

- Determine Project Goals and Objectives
- Identify Resources and Constraints
- Identify Data Characteristics and Tools
- Determine Key Study Parameters
- Specify Methods for Obtaining Data
- Develop Performance/Acceptance Criteria
- Optimize the Design for Obtaining the Data

The guidance provided in the Caltrans Monitoring Protocols is applicable to litter monitoring and should be referred to for the above steps. Additional guidance with respect to determining litter monitoring goals and objectives is provided in this section. Specific guidance related to litter monitoring is provided in the remaining sections of this document.

LITTER MONITORING GOALS AND OBJECTIVES

Storm water litter is monitored to fulfill one of two project goals:

- To monitor baseline litter patterns and loads, or
- To assess the effectiveness of a BMP designed to reduce litter.

Different motivations for monitoring litter (such as regulatory requirements) may affect the focus of the study.

Litter baseline quantity monitoring studies are useful for understanding the variation in litter loads for different drainage areas, and the relationship between storm water litter and factors such as rainfall and drainage area characteristics.

Litter monitoring that is conducted for BMP assessments provides valuable information to aid in the selection of appropriate BMPs. It is particularly important to collect consistent and

comparable data in BMP assessment studies. This allows comparisons between various technologies, processes and the selection of appropriate measures for particular installations.

BMP studies can be for either structural (e.g., pollution traps) or non-structural techniques (e.g., source reduction programs) to reduce storm water litter. These can range from studies investigating source controls, to those that reduce the transport of litter, to end-of-pipe studies aimed at providing large structural downstream controls.

The design of a litter monitoring program is dependent on the specific BMP being evaluated. For example, non-structural BMPs should be evaluated by comparing monitored litter loads from areas with an enhanced litter reduction practice (such as litter pick-up) to loads monitored from a drainage area without the enhanced BMP. For structural BMPs, litter monitoring may be conducted upstream (prior to treatment), downstream (after treatment) and sometimes within a treatment unit (by sampling material retained).

SECTION 3 SITE SELECTION

The Caltrans Monitoring Protocols should be used as guidance for site selection. Additional site selection factors to consider for litter monitoring include:

- **Document litter management practices within the drainage catchment.** Litter management practices such as litter pick-up and street sweeping should be documented during site selection, as practices may influence storm water litter loads between sites. Litter management practices should be consistent between sites for comparability.
- **Monitoring equipment access.** Litter sampling methodologies should be carefully considered during site selection. If whole event or periodic samples are collected (See Section 5), the samples can be very large, heavy, and cumbersome. For the Caltrans LMPS, the largest single event gross pollutant sample size was approximately 45 kilograms (100 pounds) by wet weight from a 457-mm (18-inch) outfall with a 0.16 hectare/0.4-acre catchment area. Samples have to be collected from the monitoring device and transported for analysis and disposal. The anticipated laboratory sample size should be considered in site selection. Vehicle access directly to the monitoring location may be necessary and the use of a boom truck, winch, or other mechanical device may be required to remove a gross pollutant from the sampling equipment.

SECTION 4 CONSTITUENT SELECTION

Litter should be considered a storm water quality constituent, similar to other chemical water quality constituents such as total suspended solids, lead, copper, oil and grease, etc. When monitoring storm water liter, monitoring devices collect gross polluntants which include litter and vegetation. During the litter analysis process (Part II, Section 12), litter is separated from vegetation and quantified. Total gross pollutants and vegetation associated with a storm water litter sample can also be quantified. Typical measurements taken associated with a storm water litter sample include:

- Total litter (by drained weight and volume)
- Total litter (by 24-hour air-dried weight and volume)

- Total vegetation (by drained weight and volume)
- Total gross pollutants (by drained weight and volume)

Depending on study objectives, it may be valuable to quantify vegetation and/or total gross pollutants in addition to litter. Table 4-1 presents a suggested hierarchy of measurements and analyses for litter monitoring. The table is divided into measurements and analysis techniques for three categories of investigation depending on different objectives of a project. Descriptions of both baseline monitoring and BMP assessment monitoring are provided.

In addition, selection of chemical water quality constituents, if desired, should be based on the Caltrans Monitoring Protocols.

SECTION 5 SELECTION OF MONITORING METHODS AND EQUIPMENT

Litter monitoring poses unique challenges regarding monitoring methods and equipment. This section outlines various options for sample collection methods and sample collection equipment. The Caltrans Monitoring Protocols should be used for other key topics covered in Section 5, "Selection of Monitoring Methods and Equipment", as the overall guidance is generally applicable to litter monitoring.

It should be noted that chemical water quality sampling systems must be designed to coordinate with litter monitoring equipment. For example, litter samples should be taken downstream of chemical water quality samples. In addition, it should be noted that runoff patterns from small freeway catchments, typical of Caltrans drainage areas, have short t_c and are not typical of larger more attenuated watersheds. Litter distribution patterns in Caltrans storm water are not well understood and these factors should be considered in selection of monitoring methods and equipment.

Table 4-1
FACTORS TO BE CONSIDERED FOR LITTER SAMPLING AND MONITORING

Level of Investigation	Minimum to Consider	Desirable	Most Detail/Specific Studies
A) Litter Load Monitoring	• Ongoing local rainfall data and measured flow data, sufficient to estimate rainfall/runoff relationships • Gross pollutants • 24-hr air-dried litter (weight and volume)	• Site-specific rainfall and flow measurements for each event	• Water samples for chemical constituents -refer to Caltrans (2000a)*.
B) Structural BMP Assessment	• Rain and flow measurements (inflow, outflow and bypass discharges) • Gross pollutants for sample analysis (see below) downstream and from in the BMP • Continuous water levels in and around the BMP • Adequate data points for statistical analysis of BMP effectiveness • Construction and operation and maintenance costs	• Composition of gross pollutants • Dry-weather litter accumulation	• Low flow upstream and downstream water samples • Water samples* from upstream and downstream of the BMP
Sample Analysis (Applicable to A or B above)	• Litter vs. vegetative material classification (without sediment) • Litter sample for lab volume and air-dried weight • Note sediments	• On-site weight and volume	• Water quality as per qualified lab procedures

* Refer to Caltrans (2000a) Table 4-1, "Minimum Constituent List for Characterization", for chemical water quality constituents as well as any project specific constituents (e.g., fecal coliforms) from Caltrans (2000a) Table 12-1.

SAMPLE COLLECTION METHODS

There are a number of common features recommended for any Caltrans litter monitoring programs in relation to collecting storm water litter samples (refer to Table 4-1). These include:

- Monitor Caltrans facility (road surface, right-of-way, etc.) surface runoff only (i.e., no non-Caltrans runoff unless specified by the objectives of the study).
- Monitor on a storm event basis (i.e., collect litter samples after every storm of a predetermined size unless otherwise specified by the objectives of the study).
- Capture all litter without restricting flow that would result in flooding.
- Perform on-site measurements and observations of captured material.
- Remove the collected sample of litter and debris to a litter laboratory for analysis.
- Perform laboratory analyses on the sample.
- Design and construct a database with the litter quantities monitored by storm events, including storm and litter characteristics in addition to site descriptions and information.

Other decisions that influence the monitoring methodology relate to the type of monitoring (baseline or BMP assessment) and the conditions at the site (e.g., catchment size and access).

For litter monitoring studies, the methodology should aim to characterize the amount of litter transported from an area. There are three options for litter monitoring in storm water: during event, post-event and periodically. The merits of each are described in Table 5-1. There are two methods for sample collection, grab and composite. Grab samples are discrete samples collected during a short time period during a storm event. Extrapolation from a number of samples can characterize the pollutant movement over a storm event. Alternatively, a grab sample can provide a 'snap-shot' of the conditions, from which some general observations can be made.

Generally, litter monitoring in storm water lends itself to total event sampling where the litter sample is collected over an entire storm event. This provides a complete sample of the litter that was transported for most events and also allows a detailed analysis to be performed on a sample. A post-event monitoring regime is expected to be best suited for the conditions in most Caltrans drainage systems and the information requirements of storm water studies.

Non-storm event variables may also be a focus of a study and need to be identified at this stage. There are many variables that could influence the amount of litter reaching the drainage network that may be investigated. Potential variables may include:

- Surrounding land-use characteristics (residential, commercial, industrial)
- Population density
- Rainfall and runoff characteristics (intensity, duration, volume)
- Traffic patterns and composition
- Wind directions and intensity
- Roadway configuration (slope, surface characteristics)
- Roadway management practices (sweeping, Adopt-A-Highway)
- Size and geometry of the drainage network
- Construction activities
- Dry weather flow/irrigation system or vehicular accident

Table 5-1
Litter Sampling Options

Monitoring Type	Advantages	Disadvantages
During Event (Grab Samples)	• Investigate transport mechanisms • Observations during events • Multiple litter samples per storm	• On-site before and during events • Difficult to predict storms • Only sub-sample litter – need to extrapolate
Post Storm Event (Whole Event Composite Samples)	• Collect complete event litter sample • Increased safety due to non-rain and daylight conditions • Compare quantities to storm characteristics	• Bypass may occur • Unknown work load (number of events)
Periodically (Composite Samples Over a Set Period)	• Predictable cost and collection schedule • Annual totals achievable	• Bypass more frequently – due to capacity • Fewer observations

Variables of concern should be considered and noted in the monitoring strategy.

Other external requirements and project specific objectives should also be noted. Examples may include any applicable regulatory requirements or having a predetermined location for a BMP installation.

SAMPLE COLLECTION EQUIPMENT

The primary design consideration for litter monitoring equipment is the size of the pipe or channel to be monitored. All monitoring sites should be located away from the freeway surface (for safety reasons) and have safe access to the drainage system. It is recommended that preference be given to sites where pipes or channels daylight to a natural or open channel (such as at the base of a fill slope). The pipe outfalls generally provide safe access and typically deliver only Caltrans facility runoff.

For all litter monitoring studies, hydrologic data (flow and rainfall measurements) should be collected. Chemical water quality analysis may be desirable depending on the study objectives. Refer to Caltrans Monitoring Protocols for details on the equipment requirements.

This section describes litter monitoring equipment in three sub-sections: pipe outfalls, open channels, and special considerations for litter BMP assessment sites.

PIPE OUTFALLS

For moderately sized outfalls (<610-mm/24-inch), a 5-mm (¼-inch) mesh bag attached to the end of the pipe is a practical, inexpensive sample collection device. Litter collects in the mesh bag as storm water passes through the pipe and into the net. This technique was used for 305-mm(12") – 457-mm (18") diameter pipes for the LMPS.

Mesh-bag litter monitoring systems should be designed not to impede hydraulic performance of the drainage system. To avoid flooding on the road surface, nets should be installed so they release when they become too full of gross pollutants or cause upstream water levels to rise. Because the monitoring nets have the potential to release, this method is suitable for litter monitoring but is not a fail safe litter collection method. The nets must be collected after each trigger storm event and therefore are maintained and emptied on a regular basis. If a net has released, it is replaced after a storm during post-storm collection procedures. In addition, during large storm events, it is recommended that nets be checked during the storm to make sure they are operating properly. If a larger long duration (generally greater than 24 hours) event occurs, nets may need to be replaced mid-storm, preferably during a period of lower flow/lower intensity rainfall.

There are several options that should be considered in designing a litter monitoring system to avoid blockage and potential flooding. One is to use an attachment strap that has a sufficiently low breaking force such that it releases when the upstream water places too much force on the net (as used in Cornelius et al.,1993; and Caltrans, 2000b, see Figure 5-1). Fixed nets may be suitable for larger systems based on site specific hydraulics and evaluation of alternate release mechanisms or a bypass system. A bypass system for outfall litter monitoring could consist of extending the outfall pipe and providing an opening in the top of the pipe for overflow. Alternative designs to alleviate flooding should be developed and evaluated on a project-specific basis. The litter monitoring equipment shown in Figure 5-1 consists of a transition or mounting collar, an oversized nylon mesh bag, and a chain-linked enclosure for security. A specially-fabricated metal collar is secured to the end of the existing pipe (beneath mesh bag in Figure 5-1)and extends approximately 150-mm (6-inches) from the drainage outfall.

The nylon mesh collection bag should be designed with consideration for potential loading capacity while minimizing flow restriction. Mesh collection bags should be designed with material sufficiently sturdy to withstand potentially large litter quantities. The litter collection bag may be constructed of a 5 mm (¼ inch), mesh able to withstand expected flow conditions. The mesh bag should be circular in design for easier fitting to circular pipe outfalls.

Figure 5-1
LITTER MONITORING NET IN LOS ANGELES USED FOR THE CALTRANS LMPS

The bag is installed over the mounting collar and secured with a nylon strap. To provide added protection, an enclosure made of chain-linked fence is used to enclose the site. The nylon bag can be accessed though the fencing by a hinged entrance on the fenced enclosure. Samples are collected after storms by removing the litter monitoring nets and replacing them with an empty net. The sample is then transported to a litter laboratory.

Benefits of this collection system include:

- No interference with water quality sampling intake tubing since the collection point is downstream of sample intake,
- Minimal construction and maintenance requirements,
- Sufficient litter storage capacity,
- Protective features discourage vandalism, and
- Minimal space requirements downstream of outfall (depends on catchment size and required bag size)

OPEN CHANNELS

Open channels present another challenge for monitoring litter because drainage areas and, therefore flows, are likely to be larger than those for outfall pipes. Also the size of the material is not governed by the size of the inlets. Material of any size can make its way into open channels. Most Caltrans drainage systems can and should be monitored prior to an open channel, however, if monitoring in channel is required the following offers some guidance.

One method that is currently being evaluated at the Caltrans DICE Study Tujunga Wash site in Los Angeles is to adapt outfall-type monitoring nets to open channel conditions. At this site, a concrete headwall is constructed across the 3048-mm (10-foot) wide channel containing three 610-mm (24-inch) PVC pipes that route flow and debris to litter monitoring nets attached to the discharge end of each pipe. In the event that the monitoring bags clog, flows can bypass the nets by overtopping the headwall or an upstream diversion weir. Similar methods could be adapted for most open channels in the Caltrans drainage system based on site-specific hydraulic design.

Site specific designs will be required for each installation as the pipe headwall needs to be low enough across the channel to not cause unacceptable hydraulic impedance during high flows. A detailed hydraulic analysis is required prior to any construction. Net and diversion systems should be designed so that flooding risk is not increased if the net systems are completely blocked with debris. The nets operate by filtering the water (a 5-mm/¼-inch mesh size should be used) until they become blocked or flows increase sufficiently to overtop the headwall.

Instrumentation is required to monitor for any storm water bypassing the litter monitoring system In this case the storm event litter sample would be incomplete and the collected sample would represent a proportion of the total amount of litter transported.

Collection of the samples after a storm event involves detaching the nets from the headwall pipes and transporting to a litter laboratory. Clean nets are then attached in anticipation of the next storm event.

BMP ASSESSMENTS

Monitoring litter for structural BMP studies is similar to baseline quantity monitoring with the exception of the placement of sampling equipment. Generally litter monitoring equipment is placed downstream of the structural BMP. Non-structural BMPs can be assessed using the same equipment in pairs of monitoring sites (one containing a BMP and the other under typical management conditions) or by alternating implementation between years of monitoring.

Structural BMPs

There are several ways to assess the performance of structural BMPs. The most reliable measure of litter removal is to measure the quantity of material that passes a BMP (with downstream monitoring) and compare it to the quantity of material that the BMP retains. If site conditions or potential flooding risks preclude downstream monitoring, a measure of the frequency and volume of flows that bypass a BMP will provide an indication of whether litter bypass may have occurred or not, presuming that any flow bypass has the capability of transporting litter past the BMP.

Structural BMPs are constructed on or around drainage systems and careful consideration must be given to any potential flooding risks. It is therefore important to collect hydraulic information such as water levels and flows in and around structural BMPs.

An important flood control component of any structural BMP is the provision of a high-flow diversion bypass. This feature serves to protect the structure from any structural damage during flood conditions and also to prevent scour and resuspension of collected pollutants from the BMP. Where applicable, instrumentation, such as level indicators and flow meters, should be installed to record when and to what extent a bypass is engaged, the water levels upstream and downstream and inside a BMP, and the flows into and out of a device (see Table 4-1).

To perform the downstream litter monitoring, the same equipment as for the baseline litter monitoring should be used (i.e. nets attached to pipes).

SECTION 6 SAMPLING AND ANALYSIS PLAN (SAP)

The Caltrans Monitoring Protocols should be followed for guidance regarding preparation of a SAP. Litter monitoring should be addressed in a similar fashion to general storm water monitoring using information in this document and project specific information. Important components of a project-specific SAP specific to litter monitoring are:

- Litter monitoring equipment description and maintenance procedures
- Storm selection criteria
- Storm event preparation procedures
- Litter sample collection procedures
- Litter laboratory coordination procedures including project specific litter analysis requirements
- Project-specific field checklists for pre-storm set-up and sample collection activities for litter monitoring (Part II, Sections 9 and 10).

PART II - IMPLEMENTING THE LITTER MONITORING PLAN

Part II describes information relevant to implementing a litter monitoring plan. The topics addressed are consistent with the Caltrans Monitoring Protocols. They are:

- Section 7 – Monitoring Equipment Installation and Maintenance
- Section 8 – Staff Training
- Section 9 – Preparation and Logistics
- Section 10 – Sample Collection
- Section 11 – Quality Assurance/Quality Control
- Section 12 – Laboratory Sample Preparation and Analysis Techniques
- Section 13 – QA/QC Data Evaluation
- Section 14 – Data Reporting Protocols

This document describes information relevant to litter monitoring for each topic.

SECTION 7 MONITORING EQUIPMENT INSTALLATION AND MAINTENANCE

For each type of litter monitoring equipment there are different site requirements and maintenance checks. This section describes the requirements for each type of litter monitoring site. The discussion includes general installation procedures, safety, and equipment checks.

PIPE OUTFALLS

Adapting moderately-sized (<610-mm/24-inch) pipe outfalls to attach litter monitoring nets is straight-forward and is a suitable technique for litter monitoring (see Part 1, Section 5 for limitations of this technique). A sleeve is placed over the pipe outlet and the netting system is placed over the sleeve. Additional site work may be required and could involve the preparation of the pipe outfall for the netting system by vegetation removal, sediment clearing or constructing a concrete pad or compact gravel base for the monitoring net (see Figure 7-1).

Figure 7-1
LITTER MONITORING NET ATTACHED TO A PIPE OUTFALL IN LOS ANGELES

Protective Enclosures

The litter monitoring equipment on pipe outfalls can be completely enclosed and protected from vandalism by the construction of a chain linked fence enclosure with access from the top or side (see Figure 7-1).

If the site includes water sampling and hydrologic monitoring equipment in addition to litter monitoring, a larger fenced enclosure will be needed for the water samplers, data loggers and flow monitoring equipment (see Figure 7-2). Caltrans (2000a) should be consulted for more information on the requirements for these enclosures.

Installation and Maintenance

The safety of all staff during installation, inspections, and maintenance is the most important consideration. The site should have been selected with safe access to the monitoring location. However, working in the drainage system may require special safety equipment. If confined space entry is required for either construction or maintenance, appropriate equipment, procedures, and training will be required.

Maintenance of litter monitoring equipment includes inspecting bags for wear, laundering as-needed, and repairing or replacing bags if necessary. Straps used to secure the bags should be replaced if worn and weeds and sediment should be cleared from the enclosure as needed.

OPEN CHANNELS

Designing and installing a headwall monitoring net system as described in Section 5 requires a site-specific hydraulic design and detailed construction plans and specifications. The system must be designed and constructed such that the risk of flooding is not increased. However, the system must retain its litter monitoring functionality by not allowing collected litter to overflow repeatedly.

The headwall that supports the nets is a permanent fixture in the bed of the storm water channel. Litter collection nets are attached to pipes that are secured in the headwall. Construction includes installing pipes within a cast-in-place concrete headwall in the storm water channel.

Figure 7-2
ENCLOSURE FOR LITTER, HYDROLOGIC AND WATER SAMPLES IN LOS ANGELES

Installation and Maintenance

After the headwall and pipes are installed, the litter collection nets can be attached to the pipes. During sample collection, each net is removed separately and replaced with an empty net. The collected gross pollutants can then be transported to a litter laboratory for analysis. Maintenance procedures are the same as for pipe outfalls.

Open channels generally should not require confined space entry. However, safety precautions should always be taken.

Protective Enclosures

The litter monitoring component of the equipment cannot be contained within a chain linked fence enclosure because of its location in the drainage channel. However, water sampling and flow equipment should be contained within an enclosure as shown in Figure 7-2.

BMP ASSESSMENTS

The installation and maintenance of the monitoring equipment for BMP assessments will be either the same as for pipe outfalls or for open channels depending on site conditions.

SECTION 8 STAFF TRAINING

Staff training for litter monitoring should be conducted following the general guidelines presented in the Caltrans Monitoring Protocols. In general, staff should be trained regarding litter monitoring preparation, sample collection, and sample delivery procedures.

SECTION 9 PREPARATION AND LOGISTICS

To ensure monitoring equipment performs well during storm events, thorough preparation is essential. The general principles for pre-storm preparation and logistics described in the Caltrans Monitoring Protocols should be followed for monitoring. Specific preparation and logistic requirements for litter monitoring are described below.

STORM SELECTION CRITERIA

Storm selection criteria should be established in accordance with project-specific objectives and in accordance with the Caltrans Monitoring Protocols. It should be noted that the selected trigger criteria should consider hydrologic factors such as catchment area, t_c, and runoff coefficients as well as the ability of flow to mobilize litter constituents. For example, the LMPS initially used a 2.5-mm (0.1-inch) storm event criterion. The initial low threshold resulted in staff mobilizing on occasions when no runoff occurred or litter was mobilized. During the second year of monitoring the criterion was increased to 5-mm (0.2-inch). This criterion was more appropriate for the mobilization and monitoring of litter in small freeway catchments in Los Angeles.

SAMPLE CONTAINERS

Litter monitoring typically requires specially fabricated sample containers, usually 5-mm (¼-inch) mesh bags that are sized on a site and/or project specific basis. Multiple sets of mesh sample bags or other specially designed containers are required to allow bags to be replaced

during frequent storm intervals. A minimum of three sets of bags is recommended and additional sets should be considered based on project-specific logistics.

SAMPLE LABELING

Sample labels should be prepared and completed prior to being attached to each sample collection bag / container (refer to Appendix F). Waterproof labels should be prepared per the Caltrans Monitoring Protocols. A standardized bag label should include the following information:

- Project Name – record the name of the Study Program, i.e., DICE
- Site Name – record the Highway number and nearest cross street
- Outfall Number – record the specific, unique monitoring site ID or outfall number where the samples are taken
- Storm Event Number – record unique storm event number, e.g., 2000-E01
- Collection Date and Time – record date and time sample was taken
- Name of Field Sampler – record name of person collecting the sample
- Non-trigger Event – check as indicated Yes _____ No _____

Analysis methods should be identified on the Chain-of-Custody Form (Section 10).

FIELD EQUIPMENT PREPARATION

The preparations for litter monitoring should be unique for each site and be contained in pre-storm procedure sheets, as shown in Appendix B. These typically include replacing clean litter monitoring nets, ensuring the site is operable and water sampling and flow equipment are working. Note that any litter/gross pollutants found in monitoring nets during pre-storm setup procedures should be collected and submitted to the litter laboratory for analysis as a "non-trigger" event sample.

Caltrans (2000a) provides a description of chemical water quality and flow sampling preparation.

SECTION 10 SAMPLE COLLECTION

POST-STORM SAMPLE COLLECTIONS

The litter sample collection procedures should be unique for each site and be contained in post-storm procedure sheets, as shown in Appendix C. These typically include collecting and labeling the litter monitoring net / container, replacing empty litter monitoring nets, making post-storm observations, and collecting water samples. Collection of the litter sample should include removal of the litter monitoring net and inspection of the pipe outfall. Any material in the pipe outfall should be left in place to be transported to the net in subsequent storms. Once the mesh monitoring bag containing the sample is removed from the outfall, the sample should be drained of free water in accordance with the following procedure before being placed in a plastic bag for transport to the Caltrans Litter Laboratory.

- Mesh bags should be gravity drained for at least two minutes and until they are substantially drained of free water (e.g., no drips for 5 to 10 seconds).

Collecting data and recording observations while on site can reveal valuable information for understanding litter transport and BMP effectiveness. Detailed data recording sheets should be developed for each monitoring site.

After a storm event a number of observations should be made. These include:

- Evidence of bypass operation
- Evidence of downstream litter accumulations
- Proportions of vegetation and litter material
- Weight and volume of gross pollutants (on-site if feasible)
- Any strange items or site conditions
- Completing standard data recording sheets

Litter samples should be collected after every storm event (within 48 hours or sooner if a rain is forecasted) larger than the specified storm event criterion. After collection, samples should be delivered to the litter laboratory for analysis. Note that litter sample bags can be heavy (the heaviest single-event LMPS sample was approximately 45 kilograms/100 pounds from a 0.4 acre catchment), so a mechanical winch or boom truck may be required for safe sample collection.

The detailed on-site data sheets should emphasize the QA aspects of the litter monitoring including handling procedures and safety requirements. Caltrans (2000a) provides a description of water sample collection procedures. In addition, equipment inspections are required on a monthly basis during dry periods to investigate whether equipment has been vandalized or otherwise damaged.

ON-SITE OBSERVATIONS

Data sheets should be developed for on-site observations and measurements like the example in Appendices B, C, and D. The data sheets should be concise, easy to use, be easily incorporated into the database. If crew members will be on site during rainy periods, all-weather paper and pens should be used. The data sheet can be in a checklist format with room for written comments.

Observations should be made at each site visits for damage, vandalism, stolen equipment, or anything in the project area that might affect the study. The area around the litter inlet and outlet should be photographed to document current field conditions.

The data sheet can also have check-off boxes for field tasks, such as general housekeeping, removal and replacement of the litter collection device, and labeling of the litter collection device.

If on-site measurements will be made, the data sheet should also contain sections for appropriate on-site weight and volume measurements. One field crew member should fill out the data sheet completely and accurately at the time of litter collection. The data sheet should be delivered to the litter laboratory manager along with the litter sample.

SAMPLE DELIVERY CHAIN OF CUSTODY

Tracking samples from the field to their final analysis destination is an essential QA measure for any sampling. Special chain of custody forms should be developed and then completed each time a litter sample changes hands. A sample letter chain of custody form is provided in Appendix E.

SECTION 11 QUALITY ASSURANCE / QUALITY CONTROL

The Caltrans Monitoring Protocols should be followed for guidance on QA/QC samples for chemical water quality. Typical chemical water quality QA/QC samples include field duplicates, laboratory duplicates, blanks, and MS/MSD samples. Of these samples, laboratory duplicates are the only QA/QC sample that can be applied to total event litter monitoring. Laboratory duplicates are achieved by performing the litter analysis procedure in duplicate at a frequency that should be determined on a project specific basis. Analyzing 10-20% of project samples in duplicate may be an appropriate target for many projects. This process is feasible for smaller sample quantities such as samples generated by outfall net type monitoring. Alternative laboratory QA/QC methods may need to be developed for large samples, such as large litter collection BMPs that are emptied 1-2 times per season or samples from open channel monitoring.

SECTION 12 LABORATORY SAMPLE PREPARATION AND ANALYSIS TECHNIQUES

This section describes steps required to prepare litter samples for transport and receipt by the litter analysis laboratory. Litter laboratory personnel must participate in the planing of all litter monitoring studies so that consideration of overall litter lab capacity and capabilities are included in the study design. Litter laboratory delivery procedures are provided in the Caltrans Litter Laboratory Coordination and Sample Delivery Protocol (Appendix F).

PRE-SAMPLING PREPARATIONS

Similar to chemical water quality samples, the Caltrans litter lab must be involved with a number of activities prior to sampling and analysis of litter samples, including:

- Selection of gross pollutant components (i.e., litter only or including measurements for total gross pollutants and/or vegetation) to be analyzed, and report formats.
- Determination of laboratory duplicates frequency and methods,
- Sampling equipment must be designed, fabricated, and provided by the monitoring project.
- Coordination with sampling team prior to each anticipated storm event. Prior to each storm, the project team must contact the litter lab to notify them of impending samples. In addition, the project team should provide any available information related to the anticipated quantity of material to be delivered (number of stations and anticipated volume for each).

ANALYTICAL METHODS

There are very few documented ways of analyzing storm water litter. For this reason Caltrans has developed guidelines for the laboratory analysis of litter. These guidelines are intended to lead to standardized methods for:

- Weight of litter (wet, and air-dried)
- Volume of litter (wet, and air-dried)
- Quantities of vegetation and litter material
- Quality assurance procedures
- Data reporting and management methods.

The 2000-2001 Caltrans Litter Laboratory Analysis Method is provided in Appendix G.

SECTION 13 QA/QC DATA EVALUATION

Several steps are important in reviewing litter data after laboratory analysis and prior to data entry. After laboratory sheets have been completed by the laboratory personnel, data sheets should be reviewed by the laboratory quality assurance officer for the following data quality checks:

1. **Duplicates** – Check that the requisite number of laboratory duplicate analyses have been performed. Previous studies have used a frequency of one per five litter samples. Duplicates should be randomly selected from the available monitoring sites for a given project.
2. **Vegetation vs. litter proportion** – The litter portion of the total sample should typically be less than 30% of the total sample by weight or volume, except for small samples.
3. **Other data recording errors** – Technician names filled in, consistent number of decimal points, data is legible.

SECTION 14 DATA REPORTING PROTOCOLS

Caltrans data reporting protocols should be followed to the extent possible for litter monitoring. Standard data reporting protocols have been developed for litter monitoring and are provided in Appendix H.

REFERENCES

- Caltrans, 1999, Solids Transport and Deposition Study (STDS) Final Report, Caltrans Doc. No. CT-SW-RT-99-024
- Caltrans, 2000a, Guidance Manual: Stormwater Monitoring Protocols (Second Edition), Caltrans Doc. No. CT-SW-RT-00-005
- Caltrans, 2000b, District 7 Litter Management Pilot Study (LMPS) Final Report, Caltrans Doc. No. CT-SW-RT-00-013
- Cornelius M., Clayton T., Lewis G., Arnold G., and Craig J., 1993, Litter associated with Stormwater Discharge in Auckland City, New Zealand, Report by the Island Care New Zealand Trust, May

APPENDICES

A - List of Californian Water Bodies Listed on EPA 303 (d) as Impaired due to Trash

B - Example Checklist for Pre-Storm Set Up of Monitoring Sites

C - Example Checklist for Post-Storm Monitoring Procedures

D - Example Checklist On-Site Monitoring Procedures

E - Sample Litter Chain of Custody Form

F - Caltrans Litter Laboratory Coordination and Sample Delivery Protocol

G - 2000-2001 Caltrans Litter Laboratory Analysis Method

H - 2001-2002 Litter Data-Reporting Protocols

Californian 303(D) List - Waterways Impaired By Trash			
Impaired River Reach Name	**Priority**	**Size Affected**	**Unit**
Arroyo Seco Reach 1 (La River to West Holly Avenue)	High	7.02	Miles
Arroyo Seco Reach 2 (West Holly Avenue to Devils Gate Dam)	High	2.53	Miles
Ballona Creek	High	4.3	Miles
Ballona Creek Wetlands	High	86	Acres
Burbank Western Channel	High	6.35	Miles
Echo Park Lake	High	23	Acres
Legg Lake	High	70	Acres
Lincoln Park Lake	High	7	Acres
Los Angeles River Reach 1 (Estuary to Carson Street)	High	2.01	Miles
Los Angeles River Reach 2 (Carson Street to Figueroa Street)	High	19.37	Miles
Los Angeles River Reach 3 (Figueroa Street to Riverside Drive)	High	7.24	Miles
Los Angeles River Reach 4 (Sepulveda Drive to Sepulveda Dam)	High	11.84	Miles
Los Angeles River Reach 5 (at Sepulveda Basin)	High	1.93	Miles
Peck Road Park Lake	High	166	Acres
Rio Hondo Reach 1 (Confl.LA River to SNT ANA FWY	High	4.19	Miles
San Gabriel River East Fork	High	12	Miles
Tujunga Wash (LA River to Hansen Dam)	High	9.68	Miles
Verdugo Wash Reach 1 (LA River to Verdugo Road)	High	3.41	Miles
Verdugo Wash Reach 2 (Above Verdugo Road)	High	5.55	Miles
Beardsley Channel (above Central Avenue)	Low	6.16	Miles
Elizabeth Lake	Low	194	Acres
Lake Hughes	Low	34	Acres
Lake Lindero	Low	13.56	Acres
Las Virgenes Creek	Low	11.47	Miles
Lindero Creek Reach 1	Low	2.2	Miles
Lindero Creek Reach 2 (above lake)	Low	4.8	Miles
Machado Lake (Harbor Park Lake)	Low	45.2	Acres
Malibu Creek	Low	9.5	Miles
Medea Creek Reach 1 (Lake to Confl with Lindero)	Low	3.01	Miles
Medea Creek Reach 2 (above cofl with Lindero)	Low	5.44	Miles
Munz Lake	Low	15	Acres
Pico Kenter Drain	Low	4.77	Miles
Revolon Slough Main Branch (Mugu Lagoon to Central Avenue)	Low	8.9	Miles
Tijuana River	Low	7	Miles
Tijuana River Estuary	Low	1	Acres
Ventura River Estuary	Low	0.35	Miles

EXAMPLE CHECKLIST FOR PRE-STORM SET UP OF LITTER MONITORING SITES

OBSERVATIONS AND ACTIVITIES **Project:** **Date:** **Time:** **Technician:**	**Site ID**	**Site ID**	**Site ID**
Damage, vandalism, stolen equipment etc. Anything in project area that might affect study. Check box and provide specific comments below			
For good housekeeping of sites, clear enclosure area of trash. Place in trash bag to dispose later.			
One field crew member replace existing (old) litter monitoring bag with clean bag. Ensure the litter bags securely fastened by strap. Chemical water quality sites must receive litter monitoring bags with Velcro flap in top.			
Same crew member to review label and initial that is accurate.			
Return labeled trash bag containing the non-trigger litter sample to lab.			
Check-in bag with lab manager or fill out bag inventory form at the litter lab.			

COMMENTS:

EXAMPLE CHECKLIST FOR POST-STORM LITTER MONITORING

OBSERVATIONS AND ACTIVITIES **Project:** **Date:** **Time:** **Technician:**	**Site ID**	**Site ID**	**Site ID**
Damage, vandalism, stolen equipment etc. Anything in project area that might affect study. Check box and provide specific comments below			
One crew member to remove existing (old) litter monitoring net and place inside plastic trash bag. Label trash bag with date and location, keep treatment and control bags together (if applicable).			
Second field member to review label and initial that it is accurate.			
Look up storm drain and note whether there is material (and type) left in the drain. Leave material in place.			
Place clean monitoring bag onto outfall. Ensure the litter bag is securely fastened by strap.			
Drain sample of free water and place in properly labeled plastic bag.			
Return collected litter samples to litter lab.			
Check-in bag with lab manager or fill out bag inventory form at the litter lab.			

COMMENTS:

EXAMPLE CHECKLIST ON-SITE MONITORING PROCEDURES

Baseline monitoring

There are a number of observations and measurements that are performed on-site at the time of clearing or during an event. Project-specific protocols should be developed to record:

1. Observe general condition of site, any obvious breakage or missed litter
2. Photograph as needed
3. Remove litter sample for transport to the laboratory
4. Fit the sampling equipment with clean set of nets
5. Record all relevant data onto recording sheets

BMP Assessment

There are a number of observations and measurements that are performed on-site at the time of clearing either for the BMP or the litter monitoring device. Project-specific protocols should be developed to record:

1. Observe general condition of site, any obvious breakage or missed litter
2. Photograph as needed
3. Check for evidence of bypass operation (e.g., debris build-up on walls, surrounding the area)
4. Remove litter from BMP for transport to the laboratory or on-site analysis
5. Ensure the BMP is ready for new events
6. Record all relevant data onto recording sheets

CALTRANS LITTER LABORATORY
STORM SEASON 2000/2001

SAMPLING REPORT & CHAIN OF CUSTODY RECORD

Consultant/Project:

Samplers:

Designated Contact:

Phone:

Sampling Information: (All information is required) Number of attachments: _____

Sample Taken Date/Time	Sampler	Site/Outfall	Sample Log Number (Consultant-Outfall #-MM/DD/YY/-TIME-####) (Lab use only)	Number of containers	Consultant/Project	Comments/Observations

Chain-of-Custody Comments

Relinquished by (print): Sign:	Received by (print): Sign:	Date / Time: Location:	
Relinquished by (print): Sign:	Received by (print): Sign:	Date / Time: Location:	Reviewed by: Date:

Litter Laboratory Coordination and Sample Delivery Protocol
Caltrans Litter Program – Storm Season 2000-2001

Date of Issue: October 20, 2000

I. Scope

The procedures presented in this protocol are intended as guidelines to coordinate the delivery of gross pollutant samples from various Caltrans field sites in the Los Angeles area to the Caltrans Litter Laboratory in Santa Ana, California. The scope of this protocol covers specific Caltrans Stormwater Projects that require litter analysis throughout the 2000-2001 storm season on a per-storm basis. These studies are the First Flush Study, the DICE Study, and the LID Study. Caltrans is also conducting studies that require litter analysis on a total storm season basis for the 2000-2001 season. The procedures for these studies will be addressed in a separate protocol. Points of Contact for each Study Team, and for the Litter Laboratory will be provided separately to facilitate coordination efforts and sample delivery.

II. Terminology

Gross pollutants – a combination of litter and vegetation collected in stormwater litter monitoring devices.

Litter – manufactured items made from paper, plastic, cardboard, glass, metal, etc. that can be retained by ¼ - inch mesh. This does not include materials that are of natural origin such as sand, soil, gravel, vegetation, etc.

Gross pollutant sample – a sample refers to the gross pollutants collected in a litter monitoring device, typically a nylon mesh bag attached to a transition collar on an outfall pipe.

III. Apparatus and Materials

The field teams for each Caltrans Study will prepare a Study-Specific Sampling and Analysis Plan for collecting stormwater and litter at specific Study sites. These plans should include details about equipment, sampling procedures, safety plans, and documentation requirements. Supplies that are specific to delivering litter/gross pollutant samples to the litter lab, and that are to be provided by each Study Team (unless otherwise noted) are presented below:

a. Sample Collection Container

Mesh Bags – nylon mesh bag with ¼-inch mesh for 12-inch, 18-inch, 24-inch, or larger pipe outfalls. If desired, samples can be delviered solely in plastic basgs (see below) to facilitate re-using mesh bags.

b. Plastic Bags

Standard size bags to contain mesh bags and/or sample, such as Hefty Steel Sak 3 Ply or equal – 30 Gallon capacity bags.

c. Labels

Waterproof, with required sample information.

d. Chain of Custody Forms – to be provided by laboratory and completed by study team.

IV. Procedures

Storm Tracking and Pre-Event Coordination

One Storm Event Coordinator (SEC) from each Study Team should be designated to call the Litter Laboratory to advise as to upcoming sample events and delivery of gross pollutant samples. A total of three phone calls should be made by each Study Team SEC to the laboratory, as follows (timing is approximate):

1. 72 hours before storm event when storm event is imminent;
2. 24 hours before storm event when field crew is mobilized; and
3. 2 hours before samples are delivered to laboratory (pre-storm and/or post-storm).

Calls to the Litter Laboratory should be made to:

Laboratory Supervisor
Lab Phone: (714) 648-2860
Pager: (714) 216-3512

If voice mail is reached, please leave a detailed message with the SEC name, project, time of call, and estimated number of samples.

Normal receiving hours are Monday through Friday from 8:00 AM to 6:00 PM. After hours, please call (714) 216-3512 and make arrangements for delivery.

Field Sampling Procedures: Pre- and Post-Storm Events

Detailed field procedures will be included in each Study-Specific Sampling and Analysis Plan. Guidance on litter collection methods is also provided in the Caltrans Litter Monitoring Guidance Manual. Some highlights that emphasize aspects of the litter collection procedures are presented below.

Once field crews are mobilized in the field, they inspect the condition of the sampling station, check the mesh bags for pre-storm "non-trigger event" litter, replace the mesh bag if necessary, and notify the litter lab of the number of non- trigger samples to be delivered.

If litter accumulated in the mesh bags before the storm event, then the mesh bags will be collected for delivery to the litter lab for analysis. The field procedure should include the following steps: drain the mesh bag to remove free-standing water, place the mesh bag inside a plastic trash bag, and label the bag for delivery. (Refer to the Litter Monitoring Guidance Manual for more detail). At some sites, the sample bags may be heavy and difficult to drain. Proper equipment and safety precautions should be followed, as appropriate for handling heavy objects.

Immediately following each storm event, the field crews must remove mesh bags from the outfall, drain the mesh bag to remove free-standing water, and place it in a plastic bag. The bag must be labeled with appropriate identifying information as specified in the Sample Labeling section below. Finally, an empty mesh bag must be placed on each outfall before the field crew leaves the site. Once all tasks are completed at the site, the bags are transported to the Litter Laboratory.

If there is any question regarding the integrity of a sample, such comments should be noted on the Chain of Custody form and field log sheets.

Sample Labeling

Sample labels should be prepared and completed before being attached to each sample collection container. Use waterproof labels (such as tyvek tags) and a waterproof marker. The label should contain the following information:

- Project Name – record the name of the Study Program, i.e., DICE
- Site Name – record the Highway number and nearest cross street
- Outfall Number – record the specific, unique monitoring site ID or outfall number where the samples are taken
- Storm Event Number – record unique storm event number, e.g., 2000-E01
- Collection Date and Time – record date and time sample was taken
- Name of Field Sampler – record name of person collecting the sample
- Non-trigger Event – check as indicated Yes _____ No _____

Sample Delivery/Chain of Custody

Samples will be received in a designated area of the laboratory. The Laboratory Supervisor will be assigned to the sample receiving area. As this person has other duties, the field crew member must notify the Laboratory Supervisor when samples are brought into the laboratory. The Laboratory Supervisor will respond immediately and proceed to receive the samples.

All samples must be accompanied with a Chain of Custody form. The form should be checked to make sure all information is filled out correctly and that the litter bags are properly labeled. The Laboratory Supervisor will:

- Sign for receipt of samples.
- Indicate time the samples were received.
- Indicate how samples were found and in what condition. Words used to describe condition can be: sealed and secured bag; torn or shattered bag; etc.
- Check to make sure that identifying information is present on the bag label.
- Once the Chain of Custody is completed, the Laboratory Supervisor will assign a unique number to each bag and note this on the Chain of Custody form and the laboratory receipt logbook.
- At this time the bags may be analyzed or placed in designated holding area for storage.

V. Quality Assurance/Quality Control

Sampling Procedure

Obtaining representative samples and maintaining their integrity are critical parts of the Caltrans Litter program. Each Study Team shall prepare a Field Sampling Plan and provide training to field personnel. The Field Sampling Plan should cover such items as proper sampling technique, equipment preparation, and appropriate containers (type, size, material, and closures).

Sample Custody

Samples are collected and transported by the respective Study Team field crews. When a sample arrives at the Litter Laboratory, the following sample identifying data will be recorded into a bound sample receipt logbook: Study Team Name and Program; Site Name/Outfall #; Storm Event Number, Sampler Name; Sampler Comments; Sample Collection Date/Time; and Submission Date/Time. At the time of receipt, the Laboratory Supervisor will assign a unique sample identification number to each sample. This number will be recorded on the Chain of Custody form and in the bound sample receipt logbook. This sample identification number will be an alpha-numeric code that includes the Study Team Name and Program; site number; collection date; collection time; and letter designations if appropriate (i.e., A, B, C, or D). Letter designations will only be required for large sites where multiple sample bags are collected from parallel outfall

pipes (e.g., Tujunga Wash), or for time-sequenced samples from a single outfall (e.g., First Flush Study).

Whenever possible the sample is analyzed immediately. If immediate analysis is not possible, the samples will be stored in the Litter Laboratory in sealed plastic bags or rubbermaid type containers, as necessary, until the samples can be processed.

VI. Laboratory Location

The Litter Laboratory is located at:

2110 East First Street, Suite 121
Santa Ana, CA 92705
Phone: 714-648-2860.
Pager (714) 216-3512

Litter Laboratory Analysis Method
Caltrans Litter Program

Date of Issue: October 20, 2000

I. Scope

This analytical method is designed to measure the weight and volume of litter discharged from storm water conveyance systems. This method also applies to weight and volume measurements of vegetation and gross pollutants associated with litter samples. This method covers wet and 24-hour air-dried samples. This method provides a standard approach to measurement techniques; terminology; equipment and supplies; data quality control; and safety. This method does not cover classifying the litter by material type or size.

II. Terminology

Gross pollutants – a combination of litter and vegetation collected in stormwater litter monitoring devices.

Litter – Manufactured items made from paper, plastic, cardboard, glass, metal, etc. that can be retained by ¼ - inch mesh. This does not include materials that are of natural origin such as sand, soil, gravel, vegetation, etc.

III. Apparatus and Supplies

a. Balances – Balances that are sensitive to the reporting limit of 1 gram or better.
b. Calibration Masses, "S" Class or traceable to ASTM Class 1.
c. Polyethylene Carboys, Graduated to 55 Liter; sensitive to 1 L for samples less than 55 L.
d. Graduated Cylinders – Cylinders sensitive to 10 ml for samples up to 1 L; sensitive to 100 ml for samples between 1 L and 10 L; sensitive to 1 L for samples greater than 10 L.
e. Digital Camera
f. Drying Trays
g. Disposable Aprons, Coats or Coveralls
h. Data Logbooks or Worksheets

IV. Procedure

Put on Tyvek protective clothing, safety glasses and gloves.

Determine and label sample bags that are subject to duplicate analysis. (Every 5th bag during the first three storm events and every 10th bag thereafter).

Determination of Tare Weight

Choose appropriate graduated cylinder. For example, for total wet weight of gross pollutants, the 55 L graduated carboy will be utilized; for small volume samples a (polystyrene weighing dish will be utilized)100 ml or 1000 ml graduated cylinder will be utilized.

Place appropriate weighing dish (cylinder) on balance.

Measure weight of (weighing dish) cylinder. Record this value on lab data sheet.

Once sample has been added to (dish) graduated calculate sample weight using the following formula.

Total Weight – Tare Weight = Sample Weight

Total Wet Weight Gross Pollutants

Determine tare weight of graduated polyethylene (PE) container. Pour contents of bag into (PE) container. Place carboy onto calibrated scale. Determine total wet weight of gross pollutants and carboy. Subtract tare weight from total wet weight and record this value on lab data sheet.

Total Wet Volume Gross Pollutants

Visually check volume of gross pollutants using volumetric graduations on the PE container. The sample shall be evenly distributed within the container. Air voids should be removed, if possible, by tapping the container on a hard surface at least three times. Note and record volume on lab data sheet.

Litter Wet Weight

Transfer gross pollutants from PE container to plastic tray at the work table. Sort gross pollutants into two groups; vegetation and litter.

Measure weight of litter material. Record data on lab data sheet.

Litter Wet Volume

Transfer litter to an appropriate graduated cylinder or PE container. The sample shall be evenly distributed within the container. Air voids should be removed, if possible, by tapping the container on a hard surface at least three times. Note and record volume on lab data sheet.

Vegetation Wet Weight

Measure weight of vegetation. Record data on lab data sheet.

Vegetation Wet Volume

Transfer vegetative materials to an appropriate graduated cylinder or PE container. The sample shall be evenly distributed within the container. Air voids should be removed, if possible, by tapping the container on a hard surface at least three times. Note and record volume on lab data sheet. Discard vegetative material into recycle trash bin.

24-Hour Air-Dried Litter Weight

Transfer litter material to drying tray. Litter should be distributed on tray such that maximum drying is achieved (i.e. do not allow materials to overlap).

Air dry litter for a minimum of 24 hours. Record date and time drying was initiated.

Label a 5 X 7 index card with storm event and site/outfall identification information. Place the index card into the card holder on the drying tray. Place the reference metric measuring devices into the drying tray. There are two measuring devices; one is placed vertically and the second runs horizontally. Standing directly above drying tray, photograph litter with a digital camera. Review digital photo to make sure text on 5 X 7 card and litter is clear. Retake photo as necessary.

Visually check litter for dryness. If litter is dry, record date and time on lab data sheet. If litter is still visibly moist, air dry for up to an additional 24 hours. Record date and time on lab data sheet.

Determine dry weight of litter. Record data on lab data sheet.

24-Hour Air-Dried Litter Volume

Transfer litter material to an appropriate graduated cylinder or PE container. The sample shall be evenly distributed within the container. Air voids should be removed, if possible, by tapping the container on a hard surface at least three times. Note and record volume on lab data sheet. Discard litter into trash bin.

Disposal

Dispose of recyclable materials into the recycle trash bin. Dispose of non-recyclable materials into the trash bin.

Thoroughly rinse drying trays, plastic trays and graduated carboys with water and allow to air dry.

V. Quality Control

Calibration of top loading balance.

Laboratory balances should have at least a 1 gram sensitivity or better. The balance must be on a stable and level base. The area surrounding the balance should be kept clean at all times. The balance calibration shall be checked three times daily using an appropriate size "S" Class weight: at the beginning of the day before sample processing; mid-day; and after sample processing at the end of the day. Document all results in the QA/QC notebook. If the balance falls out of calibration, the Laboratory Manager will be notified and corrective measures will be taken.

The single most important requirement for accurate and reproducible results is a clean balance. All balances will be cleaned on an as needed basis. All balances must be serviced and calibrated at least annually by a manufacturer's service representative.

Analysis of Duplicate Samples

In an effort to determine and maintain analytical precision at the onset of sample analysis, duplicate samples will be analyzed for both weight and volume measurements. The Relative Percent Difference (RPD) will be calculated to determine precision. As data from duplicate samples are generated the mean and standard deviation will be calculated. These values will be incorporated into a means chart for analytical precision control.

For quality control of all samples during the first 3 storm events, the weight and volume of every 5th sample shall be determined in duplicate by a different laboratory technician for each test parameter. Through the remainder of the season, the weight and volume of 10% of the samples shall be determined in duplicate.

Determinations of Relative Percent Difference

Duplicate samples are analyzed to determine precision. The relative percent difference (RPD) between the duplicate value is calculated as follows:

$$RPD\ (\%) = \left[\frac{|A - B|}{(A + B)/2} \right] x100\ \%$$

Where: A = Original Sample Result
B = Duplicate Sample Result

The RPD should be ≤15% for volume measurements and ≤5% for weight measurements; tighter limits may be imposed based on the historical results for the analysis.

Volume Measurement Control Level

Volumetric air-dried litter measurements for the Litter Management Pilot Study, (CALTRANS, June 26, 2000) were reproducible to within ±12%. For purposes of laboratory quality control, an out of control level (CL) will be defined as 15%.

As volumetric data is generated, the mean of the duplicate samples and standard deviation will be calculated. A means chart will be developed. It will include upper and lower CLs. The CL may be updated based on this data. Common practice is to use ±3*s* limits for the control level.

Weight Measurement Control Level

Air-dried litter weight measurements for the Litter Management Pilot Study (CALTRANS, June 26, 2000) were reproducible to within ±5%. For purposes of laboratory quality control, an out of control level will be defined as 5%.

As weight data is generated, the mean and standard deviation will be calculated. A means chart will be developed. It will include upper and lower control levels. The CLs may be revised based on this data. Common practice is to use ±3*s* limit for the control level.

If a measurement exceeds a control level, then a third analyst will be brought in to perform the duplicate analysis.

VI. Reporting Limits

Report weight to the nearest 1 g.

Report volume according to the sample size, as follows:

- samples from 10 ml ≤ 1 L report to the nearest 10 ml;
- samples from 1 L ≤ 10 L report to the nearest 100 ml; and
- samples greater than 10 L report to the nearest 1 L.

VII. Reference

California Department of Transportation District 7 Litter Management Pilot Study. Contract No. 43A0004C, Task Order No. 18; Caltrans Document No. CT-SW-RT-00-013. June 26, 2000.

The *2003-2004 Gross Solids Data Reporting Protocols* can be found in the Data Reporting section of this manual.

SECTION 1.4

Caltrans Monitoring Protocols: Toxicity Monitoring

OCTOBER 2001

Storm Water Monitoring & Research Program

Caltrans Monitoring Protocols Guidance Manual: Toxicity

CTSW-RT-01-056

California Department of Transportation

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SECTION 1
INTRODUCTION

This manual presents guidance for Caltrans management, staff, and contractors to use in the planning and implementation of toxicity studies for stormwater monitoring projects. The manual is designed and organized to provide step-by-step descriptions of the processes used to plan and implement successful toxicity studies specific to runoff from transportation-related facilities.

The main objective of this manual is to provide consistency in toxicity study methods among Caltrans toxicity investigations, as well as consistency in Caltrans toxicity study protocols over time. Such consistency is essential to provide for data comparability, and for ease of data entry in the Caltrans stormwater database. In addition to consistency of toxicity study methods, it is essential that toxicity data be collected so as to ensure that the data are accurate and precise. This manual therefore features detailed information on quality assurance and quality control procedures as they relate to toxicity testing.

Toxicity testing is considered a supplemental monitoring approach that can be used to support water quality monitoring, used to assess potential impacts of stormwater constituents to aquatic systems. Toxicity testing can be performed to determine if stormwater runoff is toxic prior to entering receiving waters, and additional testing can be performed to determine the fate (e.g. magnitude, areal extent, persistence) of this toxicity in the receiving water. Caltrans conducted a critical review of urban and roadway stormwater toxicity data (Caltrans, 1999a) which was used to formulate a recommended program for use of acute and chronic toxicity testing for Caltrans stormwater research and monitoring programs (Caltrans, 1999b). Existing stormwater toxicity data indicates a lack of consistency in the application of toxicity bioassays and use of a wide variety of differing toxicity test protocols. Use of United States Environmental Protection Agency (U.S. EPA) acute and chronic toxicity testing methods (U.S. EPA, 1993a, 1994) coupled with phased Toxicity Identification Evaluations (TIEs) (U.S. EPA, 1991, 1992, 1993b, 1993c) provides a standardized approach, including Quality Assurance/Quality Control (QA/QC), which allows for interpretation and application of toxicity testing results within and between studies. These standardized techniques have been applied for approximately the last ten years.

This guidance manual is specifically prepared to address the toxicity studies recommended by Caltrans and any future studies that may be designed to evaluate stormwater runoff from transportation facilities. Methods for addressing receiving water toxicity are not discussed in detail in this document. Protocols for receiving water toxicity studies may be added to this manual in the future as needed. Many of the components involved in planning and implementing toxicity studies are similar to those presented in the Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a). Therefore, this manual is organized in the same manner, with minor

variations, as the Stormwater Monitoring Protocols document, including two principal parts:

PART I: PREPARING THE STUDY PLAN

Part I of the manual is comprised of sections 2 through 6, covering topics relevant to planning toxicity studies, including: developing purpose and objectives, site selection, testing type selection, selection of sample collection methods and equipment, and documentation.

PART II: IMPLEMENTING THE STUDY PLAN

Part II of the manual is comprised of sections 7 through 10, covering topics relevant to implementing a toxicity study plan, including: sample collection, quality assurance/quality control, laboratory sample preparation and analytical methods, QA/QC data evaluation, and data reporting.

Training and preparation and logistics are additional components of implementing any stormwater study. Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) provides details concerning training and preparation and logistics for stormwater studies. These sections of the water quality document should be consulted for guidance when conducting Caltrans toxicity studies.

SECTION 2
DEVELOP PURPOSE AND OBJECTIVES

This section of the manual outlines the systematic decision-making process necessary to plan a Caltrans toxicity study that will achieve project-specific goals and objectives, including the development of appropriate DQOs. The process includes the following seven steps that summarize the systematic planning process (U.S. EPA, 2000):

- **Determine Project Goals and Objectives**
- **Identify Resources and Constraints**
- **Identify Data Characteristics and Tools**
- **Determine Key Study Parameters**
- **Specify Methods for Obtaining Data**
- **Develop Performance/Acceptance Criteria**
- **Optimize the Design for Obtaining the Data**

This process is illustrated in Figure 2-1 and each step of the process is discussed in the following subsections.

Throughout this planning process is it essential to bear in mind that runoff from transportation facilities is generally episodic in nature, and in most cases is storm-driven. The study design must therefore account for the sporadic and transitory nature of the runoff events.

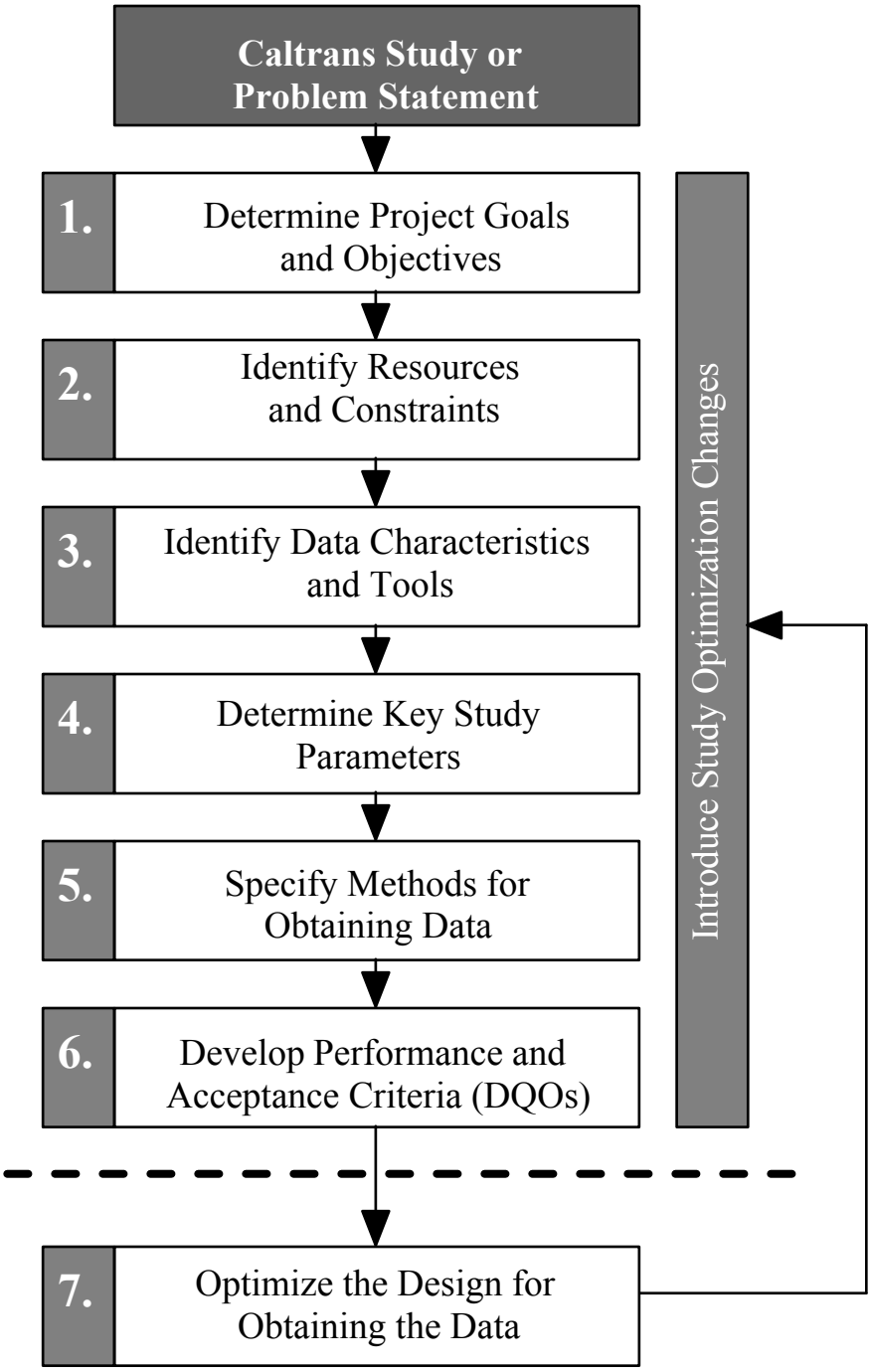

Figure 2-1. Systematic Planning Process Flow Chart

DETERMINE PROJECT GOALS AND OBJECTIVES

The overall goal(s) of the study are used to determine the specific questions that the study will be designed to answer; from these questions, specific study objectives are developed, as discussed below.

Determine Project Goal

The initial step in the development of a toxicity study plan is to determine the goal of the project based on the task order or problem statement presented by Caltrans. The overall goal of the study will in most cases have been defined previously in the Caltrans Stormwater Management Plan (SWMP) and other planning documents (e.g. Recommendations on the Use of Acute and Chronic Toxicity Testing for Caltrans Stormwater Research and Monitoring Programs, Caltrans 2000b).

Once the goal of the study is well defined, the project purpose can be stated so as to direct the project to provide data to fulfill the study goal. The goal and purpose of the study are strongly linked, and should be explicitly stated in the study plan. The purpose of the study is, generally speaking, to provide data in fulfillment of the study goals. Once the program goals and purpose are established, a set of specific study questions and objectives should be developed.

Determine Specific Study Questions/Objectives

The project goal(s) should be used to develop specific questions that the toxicity study will be designed to answer. These study questions are also in many cases previously defined in the Caltrans SWMP and other Caltrans planning documents. Specific monitoring project objectives are then developed to provide answers to the specific study questions.

Any applicable regulatory or legal program requirements must be considered in formulating the key question(s) to be used in defining project objectives. The study questions and project objectives must be specific enough to provide the basis for a detailed study design.

A primary objective of Caltrans toxicity studies will be to confirm and document the extent and cause(s) of toxicity of Caltrans stormwater discharges. This can be accomplished using a variety of approaches, depending on the nature of the specific study objectives. Typical questions that may be applied to Caltrans toxicity study projects include:

1. **Is runoff toxic to test organisms at any point during the runoff hydrograph?** In practical terms, this question asks whether the runoff is toxic at its maximum effect during a runoff event. As stormwater runoff commonly is thought to contain the highest concentrations of constituents in the initial or "first flush"

portion of the event, testing of first flush samples is often the focal point of this question.

2. **Is there a change in runoff toxicity over the course of the hydrograph?** This question pertains to the degree to which runoff toxicity varies during an event. Related studies may focus on fixed time intervals, or on discrete segments of the runoff hydrograph (i.e., the first flush, during the ascending limb, at peak flow, during the descending limb).

3. **Throughout the course of a runoff event as a whole, is runoff toxic?** Because runoff from transportation facilities is typically episodic and of relatively short duration, it may be necessary to evaluate the "average" level of toxicity associated with exposure to runoff over the course of the entire event storm or runoff event.

4. **What is the cause of the observed toxicity?** Given a demonstrated toxic effect, this question seeks to identify the cause(s). Toxicity identification evaluations are typically performed to address this question.

Sample collection approaches appropriate to address questions 1-3 are discussed in detail in ***Section 7***, question number 4 is discussed in ***Section 4***.

Other potential objectives of Caltrans toxicity studies may be related BMP effectiveness, land use types, and seasonal and/or other temporal trends. Specifically the following questions could be incorporated into toxicity studies:

5. **Are there differences in the toxicity of runoff from different locations or land uses?** Because runoff from different sources may contain differing levels of potentially toxic substances, studies may be needed to quantify related differences in toxic effect.

6. **Does BMP implementation reduce toxicity?** Toxicity testing can be an important tool for evaluating BMP performance, as toxicity study data can be used to determine if a given BMP actually removes the causes of toxicity in runoff. Knowledge of stormwater toxicity and of specific toxic agents can also aid in effective selection of stormwater BMPs, either through implementation of source controls for toxic constituents, or by the design and implementation of structural controls targeted at removal of specific toxics (Caltrans, 1999b).

7. **Are there longer-term seasonal (within a year) or temporal (between years) trends in toxicity?** Runoff quality is known to vary significantly from event to event (depending on the hydrological characteristics of the event), within and between seasons (depending upon factors related to the seasonal build-up and wash-off of pollutants, such as the antecedent dry period and cumulative rainfall to date), and from year to year (especially when comparing wet and dry years). It may be necessary to quantify the relative level and nature of toxic responses to runoff from these various temporal conditions.

Once study questions and objectives are known, specific project information needs are identified. The information needs must address any pertinent legal (court-ordered) or regulatory requirements (as specified in the NPDES permit or mandated through other state or federal regulations), and focus the study planning effort on providing answers to the key question(s) addressed by the project.

IDENTIFY RESOURCES AND CONSTRAINTS

The specific resources available and constraints pertaining to implementing the toxicity study should then be identified. Planned studies are often supported by data resources from previous studies, as well as other existing resources such as personnel, equipment, and services. Studies are typically constrained by time, available budget, physical limitations of the study area, and practical weather constraints (e.g., number of storms in a year). Toxicity studies can be further complicated by availability of test species. These resources and constraints must be well established during the planning process. At the start, the systematic planning process assumes that the fiscal constraints on a project are not primary. Practically speaking, budget constraints are known from the beginning and generally affect the scope and detail of the study. The project may also be constrained by applicable regulatory or legal requirements.

IDENTIFY DATA CHARACTERISTICS AND TOOLS

The study design should specify the expected characteristics of the data and the planned data analysis tools, so as to:

- optimize collection of data within the financial and logistical/practical limitations of the proposed study, and
- ensure that useful results will be provided to fulfill study objectives.

For example, for a TIE study the quantity and quality of the data should be sufficient to develop a clear picture of the characteristics of the toxicity (i.e. constituents, concentrations, and duration). This may equate to monitoring fewer sites (i.e., selecting representative sites) to develop detailed data, instead of monitoring a large number of sites to merely confirm that stormwater runoff is toxic.

Essential data characteristics include the type of toxicity data to be collected (e.g., screening level, acute and/or chronic), the variables affecting the data (e.g., antecedent conditions, rainfall intensity, site type and location), and the expected variability of the data (derived from previous studies when available).

Prior to the initiation of a toxicity study, a strategy should be developed for analysis of the data, directed to answering the specific study questions. The selected data analysis technique(s) may influence the type and quantities of data required to satisfy study objectives. The analysis methods applied to data collected for BMP evaluations or

characterization studies typically involve straight-forward statistical operations; however, Caltrans data may be applied to multiple applications in the future (e.g., modeling applications, comparisons to other studies, and assessments of toxicity in receiving waters), and data should be collected and presented in a manner that will allow the most versatile use of the data (see ***Section 10***).

DETERMINE KEY STUDY PARAMETERS

Key parameters of the toxicity study are determined using the information gathered in the previous steps of the systematic planning process. Key study parameters include site selection (see ***Section 3***), number of monitored storm events and their temporal distribution, characteristics of target storm events, types of samples (composite, grab, etc.) and toxicity test method (see ***Section 4***). The better these characteristics are understood, the more efficiently the monitoring data can be collected.

The monitoring locations can be selected to optimize the physical monitoring of the environmental sample stream(s); this is discussed in more detail in ***Section 3***. If possible, sites selected for toxicity studies should be monitoring stations in place for other programs which will generate supporting chemical data.

The planned numbers of sites and monitoring events are often constrained by fiscal factors; this involves not only the costs of sample collection, but also the costs of sample analysis. For this reason, the number and types of toxicity tests should be considered in the early stages of project planning (see ***Section 4***), so the costs of the appropriate sample collection and analysis can be factored into the expected cost per monitoring event.

The types of storms to be monitored and optimal temporal distribution of monitoring events also should be considered during project planning. For example, if the project objectives include characterizing seasonal variation in stormwater toxicity, the monitoring events must be adequately distributed throughout the period(s) of interest. Besides seasonal distribution, a number of variables can be considered when selecting types of storms to monitor. These variables could include storm size (rainfall amount), duration, and antecedent conditions (such as number of days since the previous rainfall). Storm selection criteria should be developed to guide project managers in the appropriate selection of monitoring events during the monitoring season.

In addition to considering the types of storms to monitor, the timing of sample collection (as it relates to the event hydrograph) should also be considered. Possible approaches may include collection of a single grab sample during the initial or “first flush” portion of the event, collection of single grabs during discrete portions of the hydrograph (ascending, peak, and/or descending portions), collection of multiple grab samples at points throughout the event, or collection of an event-length composite sample.

SPECIFY METHODS FOR OBTAINING DATA

Once the key study parameters are known, appropriate data collection methods are specified (see ***Sections 5, 7 and 9***). This includes the types of samples collected and sample collection techniques (flow-based composite, automated sampling, grab, etc.), the equipment used to collect the samples, the toxicity testing methods, QA/QC procedures, and the specific procedures to be followed in accordance with the physical layout of the study site (e.g., which discharge flows best characterize the highway runoff and the practical considerations for collecting samples at that site). The sample collection methods must consider the method specifications for sample handling, containers, sample type, holding time, and preservation (see ***Sections 5*** and ***9***).

DEVELOP PERFORMANCE/ACCEPTANCE CRITERIA

The central goal of any toxicity study is to provide scientifically defensible data in fulfillment of program objectives. This goal is best achieved through scientific design of the study and sound technical planning. Statistical methods may be used in the design of the study to determine the optimum number of sampling sites and sampling events (monitoring frequency) that will be needed to fulfill specific project objectives. Performance acceptance criteria, also known as DQOs, should be specified for the project, to help ensure that the data produced by the study will be useful in addressing study objectives, and to establish meaningful confidence levels for the monitoring data.

DQOs, as defined for this guidance document, specify the quality of data required to support the specified objectives of toxicity studies. DQOs generally are used to determine the level of error considered to be acceptable in the data produced by the study; in large measure they are used to specify acceptable ranges of field sampling and laboratory performance. The DQOs should be specified in the project Data Quality Evaluation Plan (DQEP) (see ***Section 9***) and referenced in the Sampling and Analysis Plan (SAP).

A detailed discussion of DQOs for Caltrans stormwater monitoring projects is presented in the Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a). In general, the same systematic approach for determining DQOs for stormwater monitoring projects applies to establishing DQOs for toxicity studies. For the purposes of this Guidance Manual, DQOs refer to the set of specific performance and acceptance criteria applied to field and laboratory activities associated with toxicity studies. The DQOs developed for each project establish measures of acceptable performance and data quality for the collected data, and this guidance manual describes procedures by which toxicity data should be generated and evaluated.

USEPA methods for toxicity testing outline test acceptability criteria as well as specifications for test conditions. These parameters are discussed in detail in ***Sections 8 and 9***. Any failure to meet test acceptability criteria or any deviation from test

specifications must be noted and data must be evaluated in light of these deviations (*see* ***Section 8***).

Analytical precision and accuracy are often determined by historical laboratory performance; in some cases interlaboratory studies conducted by USEPA or others are used to set these limits. Each project should include a thorough QA/QC data review and evaluation to assess project success in meeting accuracy and precision acceptance criteria (see ***Section 8***). Specifically, the following QA/QC parameters should be reviewed:

- Holding times
- Test acceptability criteria
- Contamination check results (field, bottle, and equipment blanks)
- Precision analysis (laboratory duplicates, reference toxicants)

Representativeness criteria for testing of event-length composite samples are discussed in detail in ***Section 7*** and are based on storm size, percent storm capture, and total number of composite sample aliquots.

OPTIMIZE THE DESIGN FOR OBTAINING THE DATA

Ideally, the systematic planning process can be iterative for each project, as needed. It is possible to modify study parameters, with approval from the Caltrans task order manager, to optimize data collection to meet study objectives, based on newly collected data and field observations. This can sometimes be done during natural break points of the study (e.g., at the end of the wet season), when data are analyzed and achievement of study objectives is assessed. In some cases, the collected information may indicate modification of the study goals, the collection methods, the toxicity test type or species, or the types and frequency of runoff events sampled.

The systematic planning process, as applied to the Caltrans Statewide Stormwater Monitoring Program, is a synthesis of currently evolving EPA guidance and the practical considerations of overall goals (Caltrans, 2000a). The seven-step process described in this section is the starting point for structuring specific Caltrans toxicity studies. The remaining sections of this manual carry out and build on these steps, from site selection to QA/QC data evaluation. The seven step process is iterative, with the final step providing for feedback to any of the previous six steps.

SECTION 3
SITE SELECTION

Selection of sites for Caltrans toxicity studies should start with evaluation of monitoring stations that exist for other programs (e.g. existing Caltrans stormwater monitoring locations). If possible these existing sites should be selected for toxicity studies to save time and resources and to provide supporting chemical data. Some modifications and use of different sample collection methods may be required at existing runoff monitoring sites to accommodate the larger sample volumes needed for toxicity testing (see ***Section 7***). Site selection will also depend on the program objectives and any regulatory or legal requirements. However, once these criteria have been used to establish the number and type(s) of monitoring sites, consideration of the following items will help ensure selection of the most appropriate monitoring locations for toxicity studies:

- **Representativeness**
- **Best Management Practices (BMP) Effectiveness**
- **Site Visit**

This section focuses on use of pre-existing Caltrans runoff monitoring sites for toxicity study sample collection. Stormwater monitoring program site selection is discussed in detail in Part I, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a), including information on the above items as well as personal safety, site access, equipment security, flow measurement capability, electrical power and telephone, and non-Caltrans sources. Site selection for receiving water studies is not included in this manual.

REPRESENTATIVENESS

Types of runoff sampling sites specified for Caltrans monitoring may include highway sites (freeways, expressways and/or conventional highways), maintenance yards, park-and-ride lots, or construction sites. It is important to select specific monitoring sites that are representative of typical Caltrans operations for these site types. The Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) provides guidance on site characteristics to consider when selecting representative monitoring sites.

For toxicity studies it may be useful to select sites that discharge directly into identifiable receiving water bodies. This would support future toxicity testing that may be conducted to investigate the potential receiving water impacts of Caltrans discharges.

BMP EFFECTIVENESS

Studies of BMP effectiveness involve different objectives than those for general stormwater discharge monitoring. The goals of BMP monitoring programs are somewhat different as well. The Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) provides detailed information concerning the selection of sites for BMP performance monitoring.

Site selection for BMP evaluation will depend upon the type of BMP (e.g. structural or non-structural). Structural BMPs typically have well-defined boundaries and may be relatively easy to monitor. When evaluating structural BMPs, monitoring locations should be located immediately upstream and downstream of the structure. This will allow for comparison between the toxicity of stormwater influent of the BMP and stormwater effluent of the BMP.

Non-structural BMPs (e.g. street sweeping, catch basin cleaning, illicit discharge elimination) may be more difficult to monitor because they can be influenced by many factors that cannot be "controlled", and may not have clearly defined inlet and outlet flows. In such cases, it may be necessary to determine the toxicity of runoff at the same sites before and after BMP implementation.

It is assumed that any toxicity testing used to measure BMP effectiveness would be conducted on sampling stations from existing Caltrans BMP pilot studies.

SITE VISIT

Each potential monitoring site should be visited to confirm the expected site characteristics and verify whether the site is suitable for the needs of the toxicity study. When possible, a visit should be conducted during or after a storm, when the discharge flow conditions can be observed. A wet-weather visit can provide valuable information regarding logistical constraints that may not be readily apparent during dry weather. However, a dry weather visit should also be conducted to observe any non-stormwater flows. If any significant dry weather flows are present this should be noted and considered during final site selection.

Because some types of toxicity tests require large sample volumes, especially if TIE follow-up is planned, the sample station equipment should be evaluated to ensure that adequate sample collection is possible. See ***Section 9*** for sample volume requirements.

SECTION 4
TESTING METHOD SELECTION

To select the specific type of toxicity tests to be conducted for a given toxicity study, the following items should be considered:

- **Project Objectives and Resources**
- **Regulatory and Legal Requirements**
- **Pollutant Sources in the Catchment Area**
- **Existing Monitoring Data**
- **Beneficial Uses/Impairments of the Receiving Water**
- **Constituents to Be Used for Data Interpretation**
- **Typical Toxicity Methods**

Each of these considerations is discussed below, followed by a list of the suite of possible toxicity tests Caltrans may use for toxicity studies.

A summary schematic of the process followed in determining the types of tests to be conducted is shown in the flow chart in Figure 4-1. The procedure calls for examining the purpose and goals of the project, legal requirements, existing permits, and any expected or likely toxicants. Consideration of sampling and analysis costs (i.e., available project resources) is included as a final step in making this determination, as most projects are fiscally constrained.

PROJECT OBJECTIVES AND RESOURCES

The types and number of toxicity tests selected for a given study will ultimately depend upon the objectives and available resources (e.g. personnel, funds, time). As discussed in the Recommendations on the Use of Acute and Chronic Toxicity Testing for Caltrans Stormwater Research and Monitoring Programs (Caltrans, 1999b), primary purposes of Caltrans toxicity studies may be to:

- Confirm and document the extent of toxicity of Caltrans stormwater discharges;
- Identify constituents causing toxicity in Caltrans stormwater discharges;
- Determine the effectiveness of BMPs in the removal of toxicity from Caltrans stormwater discharges;

- Interpret toxicity data with respect to potential receiving water impacts; and
- Determine toxicity/bioaccumulation effects of stormwater sediments deposited into receiving waters.

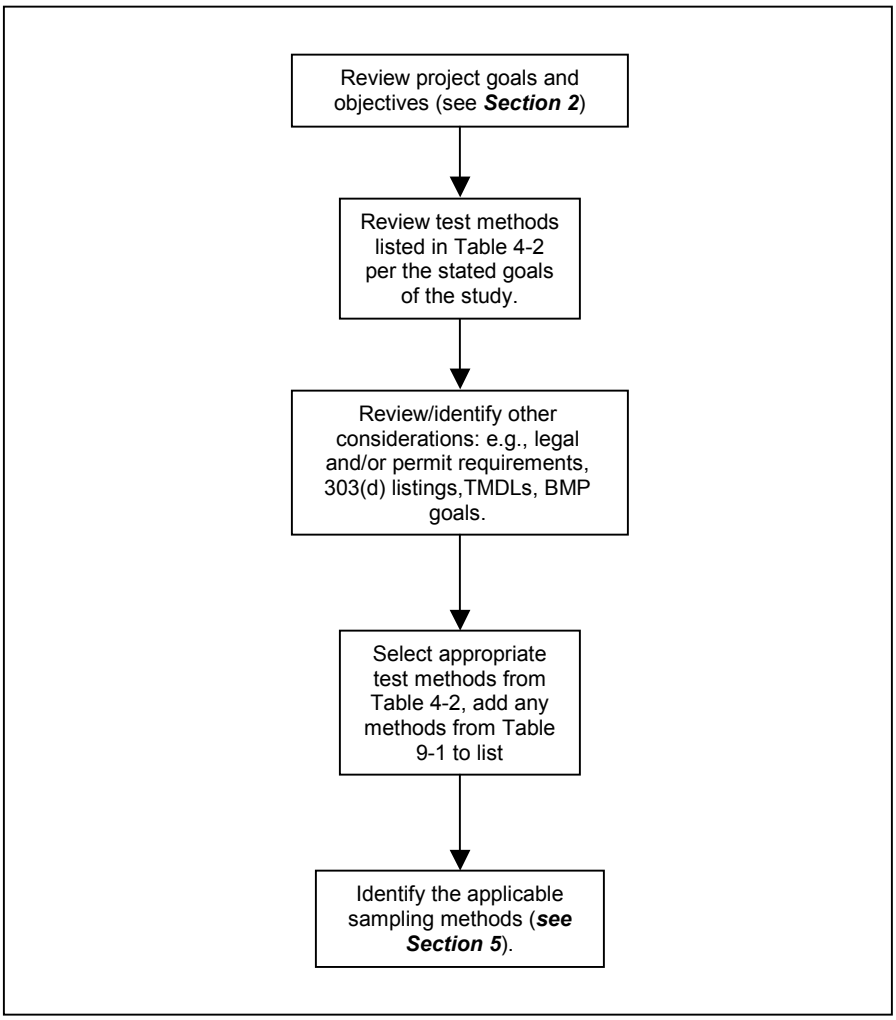

Figure 4-1. Flow chart of toxicity test method selection process.

REGULATORY AND LEGAL REQUIREMENTS

Currently, specific toxicity requirements are not outlined in the Caltrans Statewide Stormwater NPDES permit. The permit does state that discharges shall not cause or contribute to violations of water quality objectives nor shall they cause certain conditions to occur which create a condition of nuisance or water quality impairment in receiving waters. As a permitted discharger, Caltrans may be obligated to fulfill related requirements under state or federal regulations, specifically the State Water Code or the Clean Water Act. Caltrans also may be subject to relevant court ordered legal requirements.

POLLUTANT SOURCES IN THE CATCHMENT AREA

Identifying potential constituent sources in the catchment area can aid in identification of potential toxicants and the selection of toxicity test methods to be utilized. Caltrans projects may involve monitoring of runoff from highways, maintenance yards, park-and-ride lots, and construction sites. The potential constituent sources associated with each of these facilities may differ. A detailed description of the types of constituents expected from highway runoff, maintenance yards, rest areas, park-n-ride lots, and construction sites is provided in Part I, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a).

If particular constituents are expected from certain catchment areas, this may help in the selection of the species tested and may guide TIE efforts. According to toxicity studies conducted by others, for land-use categories including urban residential, commercial, or light industrial most of the observed toxicity has been attributed to organophosphate insecticides (e.g. diazinon, chlorpyrifos). Evidence has included analytical chemistry and TIE confirmation (See Table 4-1). A limited number of studies have focused on runoff predominately or exclusively from roadways or highways (See Table 4-1).

As shown in Table 4-1, a review of the literature revealed that both urban and highway stormwater samples caused toxicity due to concentrations and combinations of metals, non-polar organic compounds, and/or suspended solids. Salt compounds used for deicing roads, and organic compounds used for deicing aircraft were both found to be toxic in standardized bioassay tests. However, in several cases, the toxicant was not identified. Additionally, toxicity associated with highway runoff samples was related to a number of factors, including the traffic load (average daily traffic (ADT)) and the length of time between storms that flushed materials from roads (Caltrans, 1999b).

Table 4-1. Stormwater Runoff Toxicity: Urban/Suburban/Mixed and Transportation Related Runoff Studies

Author (Year)	Location	Land Use/ Sample Source	Species[1]	Bioassay Type	Results/Suspect Toxicants
URBAN/SUBURBAN/MIXED					
BASMAA (1996)	CA-SF Bay Area	Industrial	***Ceriodaphnia*** *Pimephales* *Selenastrum*	Chronic Chronic Chronic	*Ceriodaphnia* toxicity was attributed to diazinon, non-polar organics
ToxScan (1998)	CA-Stockton	Urban (sumps)	***Ceriodaphnia*** ***Selenastrum***	Acute Chronic	Diazinon, malathion (*C.dubia*) non-polar organics, Zn (algae)
ToxScan (1996a)	CA-Stockton	Urban (sumps)	***Ceriodaphnia***	Acute	Diazinon, chlorpyrifos, malathion, weak evidence of volatile/surfactant and metals
ToxScan (1995a,b)	CA-Sacramento	Reservoir and river samples	*Ceriodaphnia*	Chronic	No toxicity observed
ToxScan (1993a,c)	CA-Sacramento	Urban creek	***Ceriodaphnia***	Acute	Non-polar organics, metals
ToxScan (1993b)	CA-Sacramento	Urban creek and river samples	*Ceriodaphnia* *Pimephales* *Selenastrum*	Chronic Chronic Chronic	See Toxscan 1993 a,c (TIEs performed for *C.dubia* only. Slight reduction in growth was observed for *P. promelas* and *Selenastrum* showed no effects)
ToxScan (1992a)	CA-Sacramento	Urban creek and river samples	***Ceriodaphnia*** *Pimephales* *Selenastrum*	Chronic Chronic Chronic	TIEs were not conducted. All river samples were toxic to *C.dubia*, river samples were not toxic. *P. promelas* growth was effected in both river and creek samples. River and creek samples effected Selenastrum growth, creek samples were more toxic.
ToxScan (1996b,c)	CA- Contra Costa	Urban stream	*Ceriodaphnia*	Chronic	TIEs not conducted. Both *C.dubia* survival and reproduction were effected.
ToxScan (1995c,d, e)	CA- Contra Costa	Urban stream	*Ceriodaphnia*	Chronic	TIEs not conducted. Both *C.dubia* survival and reproduction were effected.
ToxScan (1994a,b,c)	CA- Contra Costa	Urban stream	*Ceriodaphnia*	Chronic	TIEs not conducted. Both *C.dubia* survival and reproduction were effected.
Schiff & Stevenson (1996)	CA-San Diego	Urban creek	*Ceriodaphnia*	Chronic	TIEs not conducted. *C.dubia* reproduction was effected.

Table 4-1. cont.

Author (Year)	Location	Land Use/ Sample Source	Species[1]	Bioassay Type	Results/Suspect Toxicants
SCCWRP (1996)	CA- SoCal	Urban creek compared to undeveloped area	*Haliotis* ***Strongylocent -rotus***	Chronic Chronic	Urban creek samples were consistently more toxic. TIE results presented in Jirik et al. 1998 (below)
Jirik et al. (1998)	CA- SoCal	Urban creek compared to undeveloped area	***Strongylocent -rotus***	Chronic	Zn, Cu
Lopes & Fossum (1995)	AZ	Mixed use	***Pimephales*** *Ceriodaphnia*	Acute Acute	Surfactants/organics, Cu & Zn (*P. promelas*) Samples not toxic to *C.dubia*
Medeiros et al. (1984)	MA	Urban stream	*Pimephales*	Chronic	TIEs not conducted.
TRANSPORTATION					
Bogdanic (1997)	CA- SF Bay Area	Construction sites and freeway	*Pimephales*	Acute	No toxicity observed
BASMAA (1996)	CA- SF Bay Area	Two highway sources	***Ceriodaphnia*** *Pimephales* *Selenastrum*	Chronic Chronic Chronic	Non-polar organics, Metallo-organics
Fisher et al. (1995)	MD	Airport	*Pimephales* ***Daphnids***	Acute Acute	One episode of toxicity to daphnids; Ethylene glycol suspect toxicant
Lord (1987)	US	Highways with various Average Daily Traffic (ADT) from 12,000 to 120,000	*Pimephales* *Selenastrum* *Gammarus* *Hexagenia* *Daphnia*	Acute Chronic Acute Acute Acute	Metals (*Selenastrum*). Toxicants not determined for other species. No toxic response to *P. promelas* or daphnids. Some effect to *Gammarus* and *Hexagenia* but not related to ADT.
Portele et al. (1982)	WA	Highways with various ADT BMP-grass swale	*Selenastrum* *Daphnia* *Oncorynchus*	Chronic Acute Acute	Toxicity to *Selenastrum* observed at one site. Daphnia toxicity at one site; filtration of sample did not change toxicity. Toxicity to *Oncorynchus* observed for unfiltered samples but not filtered samples or samples that passed through grass swale.
Little et al. (1982)	WA	Highway	***Selenastrum***	Chronic	Pb, Cu, Zn
Winters and Gidley (1980)	CA	Highway	**Indigenous Algae**	Chronic	Zn, Pb (metals) Worst inhibition of growth at high traffic volume (185,000 ADT). Lower ADT and freeway samples with short dry period were stimulatory.
Caltrans	Districts 6, 8 and 10		*Ceriodaphnia*	Acute	Not reported

Table 4-1. cont.

Author (Year)	Location	Land Use/ Sample Source	Species[1]	Bioassay Type	Results/Suspect Toxicants
Caltrans (UC Davis, 1999)	CA – Modesto	Agricultural, urban, highway	*Ceriodaphnia* *Pimephales* *Selenastrum* *Oncorynchus*	Acute and Chronic	Diazinon (*C. dubia*), None identified (*P. promelas*)
Caltrans	Statewide	Caltrans facilities including rest areas, maintenance yards, highway, and park-and-rides.	*Ceriodaphnia* *Pimephales* *Selenastrum*	Chronic Chronic Chronic	Toxicity was observed at all but 2 sites. Non-polar organics implicated in 9 *P.promelas* and 9 *C. dubia* TIEs, metals implicated in 4 *P.promelas* and 1 *C.dubia* TIEs. Metabolically activated pesticide implicated in 9 *C.dubia* TIEs. The pesticide was suggested for highway sites, park-and-ride, and maintenance yards. The cause of *C.dubia* toxicity was not identified for 5 of the sites.
Caltrans	CA – Navaro		*Ceriodaphnia* *Pimephales* *Selenastrum*	Chronic Chronic Chronic	Not reported

1 If applicable, the most sensitive species and/or species tested in TIEs are highlighted in bold.

EXISTING TOXICITY DATA

Table 4-1 provides a summary of the results of stormwater runoff toxicity studies conducted by Caltrans and others, including information on the species tested, test duration (i.e. acute or chronic) and significant findings of TIEs.

The existing data from these previous studies forms the essential basis for the list of Caltrans toxicity test types specified in Table 4-2. Note that the list of toxicity test types applies to Caltrans runoff studies only, and therefore assumes a freshwater matrix. In some cases it may be prudent or necessary to add additional test methods, for example to address legal requirements or specific receiving water concerns.

BENEFICIAL USES/IMPAIRMENTS OF THE RECEIVING WATER

Receiving water toxicity studies are not discussed in detail in this document, but information may be incorporated into this document once Caltrans begins to evaluate toxicity in receiving waters. In turn, this document focuses on freshwater species only; which will be applicable for use for freshwater receiving water studies.

Toxicity data on stormwater discharges, and on dilutions with the receiving water, can give a more direct measure of potential beneficial use impacts than water chemistry data alone. Toxicity test organisms integrate the individual toxicants biologically to provide effects-based response information, as opposed to inferred responses from chemical constituent data. Toxicity data are therefore useful to demonstrate whether beneficial uses are being protected. For such purposes, data will be required so that results can be interpreted for both freshwater and marine receiving waters of importance to California. Marine and estuarine species must be considered if toxicity studies are conducted to evaluate marine and estuarine receiving waters. The effects of dilution by receiving waters, the toxicity in the receiving water from runoff from non-roadway sources, and the concept of exposure duration also need to be considered (Caltrans, 1999b).

Table 4-2. List of Freshwater Toxicity Test Types[1]

Bioassay Type	Species	Duration	Method	Endpoints Measured	Description/Application
Zooplankton	▪ *Ceriodaphnia dubia*	Acute (24, 48 or 96 hrs)	EPA/600/4-90/027	Survival	*Ceriodaphnia* has been shown to be sensitive to stormwater in many studies throughout California (SCCWRP, 1999). This species represents a taxonomic group (crustacean) that is an important member of freshwater aquatic communities.
Fish	▪ *Pimephales promelas* (Fathead Minnow) ▪ *Oncorhynchus mykiss* (Rainbow Trout)[2]	Acute	EPA/600/4-90/027	Survival	Direct link to beneficial uses and these species represent a taxonomic group (teleost) that is an important member of freshwater aquatic communities.
Zooplankton	▪ *Ceriodaphnia dubia*	Chronic (7 days)	EPA/600/4-91/002	Survival, reproductive success, behavioral changes	*Ceriodaphnia* has been shown to be sensitive to stormwater toxicity in many studies throughout California (SCCWRP, 1999). This species represents a taxonomic group (crustacean) that is an important member of freshwater aquatic communities.
Fish	▪ *Pimephales promelas* (Fathead minnow)	Chronic (7 days)	EPA/600/4-91/002	Survival, growth (weight), behavioral changes	Direct link to beneficial uses and these species represent a taxonomic group (teleost) that is an important member of freshwater aquatic communities.
Algal	▪ *Selenastrum capricornutum*[3]	Chronic (96 hrs)	EPA/600/4-91/002	Growth	Growth is measured as an indicator of eutrophication potential. Also, certain toxicants could suppress growth and testing could be structured to get insights on the relative influences of nutrients and toxicants in diverse water samples (Horner, 1997).

1 Listed tests include the freshwater tests most commonly used in past transportation-related runoff studies.
2 Rainbow trout were used by Caltrans to determine developmental toxicity to an indigenous species.
3 Species name has been changed to *Raphidocelis subcapitata*.

CONSTITUENTS TO BE MEASURED TO SUPPORT TOXICITY TEST DATA

Field Measurements

At the time of toxicity sample collection, field crews should measure temperature, pH, dissolved oxygen (DO), and electrical conductivity. Methods and equipment for measurement of these parameters are discussed in ***Sections 5 and 7.*** Measurement of these parameters in the field can be used to assess changes in these parameters from the time of sample collection to the time of test initiation. This information may be valuable in determining potential changes in toxicity (see discussion below).

Laboratory Measurements

USEPA toxicity testing methods specify limits for temperature, dissolved oxygen (DO), and pH values during testing. Variations in these parameters in the test solutions can cause changes in the toxicity of the sample and are therefore monitored closely to ensure measurements are within the specified limits. The measurements required by U.S. EPA methods are as follows:

Adverse effects of low DO concentrations, high concentrations of suspended and/or dissolved solids, and extremes of pH, alkalinity, or hardness, may mask the presence of toxic substances.

Acute tests:

- At a minimum, pH and conductivity are measured in the sample and the control.
- It is also recommended that total alkalinity and total hardness be measured in the sample and the control.
- DO should be measured in the sample prior to use and should be near saturation. See ***Section 9*** for information on sample aeration.

Chronic tests:

- DO is measured at the beginning and end of each 24-hour exposure period in at least one test chamber at each test concentration and in the control. See ***Section 9*** for information on sample aeration.
- Temperature and pH are measured at the end of each 24-hour exposure period in at least one test chamber at each test concentration and in the control.
- Temperature should also be recorded continuously or observed and recorded daily for at least two locations in the environmental control system or the samples. Temperature should be measured in a sufficient number of test vessels at least at the end of the test to determine the temperature variation in the environmental chamber.

- pH is measured in the sample each day before test solutions are made.
- It is also recommended that conductivity, total alkalinity, and total hardness be measured in each sample and the control.

U.S. EPA toxicity testing protocols recommend measurement of total ammonia and residual chlorine; however, this may not be necessary for stormwater samples unless these are suspect toxicants (i.e. measurement of these constituents is included in EPA guidance which was developed primarily to characterize municipal and industrial effluents, which can contain significant concentrations of these constituents).

Specialized chemical analyses may be conducted on selected toxicological samples to assist in the characterization and confirmation of specific compounds that may be responsible for stormwater toxicity. For example, if the TIE process identifies pesticides as the primary toxicants, the toxic sample can be analyzed for pesticide concentrations. However, it is important to be aware of sample holding times and other requirements (e.g. preservation) for chemical analyses.

TYPICAL TOXICITY METHODS

It is common to test stormwater samples using both acute and chronic test procedures. Both acute and chronic toxicity tests have been used in transportation related stormwater runoff studies (see Table 4-1), most commonly using the standard three freshwater species *Ceriodaphia dubia* (zooplankton), *Pimephales promelas* (fish), and *Selenastrum capricornutum*[1] (algae, chronic only). Based on a review of the existing data, the initial toxicity study approach suggested by Caltrans (1999b) recommended use of three-species chronic protocols to establish the most sensitive species for subsequent monitoring. Additionally, it was recommended that screening-level bioassays (using undiluted runoff samples) be used initially, so that the existence of toxicity can be confirmed and characterized in the most cost-effective manner.

Identification of the causative agents in toxic samples can be performed utilizing TIE methods outlined by U.S. EPA (1991, 1993a, 1993b). Phased TIEs include a set of procedures for characterizing the physical/chemical characteristics of the toxicants in a sample, as well as the variability associated with the type and concentration of compounds that cause toxicity in the sample.

A brief summary of acute testing versus chronic testing, screening level versus dilution tests, selection of appropriate species, and TIEs is presented below.

Details of each toxicity test method are provided in ***Section 9.***

[1] This species name has been changed to *Raphidocelis subcapitata*.

Acute vs. Chronic

There are advantages and disadvantages to both acute and chronic toxicity testing. The main advantage of acute testing is cost (typically less than half the cost of chronic). Acute tests provide a more immediate result than chronic tests, but also provide data on only one endpoint (survival). Chronic toxicity tests are considered more sensitive because they focus on other endpoints (e.g. reproductive success, growth) in addition to survival.

Acute vs. Chronic Toxicity

Acute toxicity describes the adverse effects resulting from a single or short-term exposure to a substance. The exposure period for most acute toxicity tests is less than 96 hours, depending on the test species. Lethality is the endpoint measured, but sublethal effects such as behavior or physical defects are also recorded.

Chronic toxicity describes the adverse effects from repeated exposures to a substance over a longer period of time. The exposure period for most chronic toxicity tests is 4-7 days. The effect can be measured in lethality, impaired growth, reduced reproduction, etc.

It may appear that acute toxicity tests would be more appropriate for stormwater samples because runoff events are typically relatively short-term events. However, chronic tests may be appropriate in instances where events occur frequently (e.g. multiple storms per month). This is true because some of the effects of stormwater discharges are associated with organic and toxic pollutant accumulations over a long time and are not associated with individual runoff events (Field and Pitt, 1990 as cited in Johnson et al. 1998).

Depending upon the objectives and available resources of a given toxicity study, one possible approach might include conducting acute tests initially to determine if acute toxicity exists; this would avoid wasting the costs of setting up a chronic test. If acute toxicity is not observed, subsequent testing could be conducted under chronic exposure conditions.

Screening Level vs. Dilution Tests

Stormwater samples collected for toxicity testing may be tested either at the full (100%) concentration only (screening test) or in a dilution series. Screening level tests may be considered (either acute or chronic) as an initial approach to determining runoff toxicity. This approach is the most cost-effective to confirm the existence of toxicity in runoff from Caltrans conveyance systems. Dilution series tests could then be conducted on samples from sites that demonstrated consistent and significant toxicity during screening. Testing a dilution series on samples from these sites would allow for quantification of the toxic response.

Selection of Test Species

The following criteria may be used to assist in selection of appropriate test species (SCCWRP, 1999):

- Sensitivity to stormwater toxicants
- Comparability with prior or planned data
- Representativeness of local fauna or key animal groups
- Suitability for TIE methods

It is also important to consult with the laboratory conducting the testing to determine if the selected species is easily cultured in the laboratory and/or is available throughout the year from commercial sources. Additionally, indigenous species may only be used if culturing and testing methods have been developed for the selected species. However, EPA allows the use of indigenous species only where state regulations require their use or prohibit importation of the species provided by EPA guidance (EPA, 1993). Use of indigenous species other than those recommended by EPA guidance requires side-by-side toxicity tests with reference toxicants and/or runoff samples to ensure that the species selected are at least as sensitive as the recommended species.

TIEs

Identification of the constituents present in stormwater samples causing toxicity is an important component of toxicity studies. Identification of toxicants in runoff from Caltrans conveyances may provide information on the origin of the toxicants, and suggest whether they are products of transportation-related activities or whether they are deposited by rainfall or dustfall. Toxicant identification may also help in the design and effectiveness evaluation of BMPs for toxicant control.

U.S. EPA has developed a series of procedures (Phase I, II, and III TIEs) for characterizing, identifying, and confirming the identity of suspect toxicants in toxic samples. The phased TIE approach develop by U.S. EPA seeks to identify toxicants in a sample via a series of manipulations and associated bioassays which target a systematically narrowing list of suspect toxicants. Phase I TIE tests are used to determine the nature of the components causing toxicity and to identify the possible chemical category of the toxicant(s) (e.g. metals, nonpolar organics, volatiles). Once the likely chemical category is identified Phase II manipulations are used to identify the specific toxicant(s). Additional monitoring data (e.g. physical and chemical, pollutant source) may provide information that can be used to direct Phase II testing. Phase III is used to confirm that the suspect toxicant(s) identified in Phase II is/are indeed the true toxicant(s).

TIE methods were initially developed to identify toxicants in acutely toxic samples. However, Phase I TIE methods for chronically toxic freshwater samples have been

published by U.S. EPA (U.S. EPA, 1992). Phase II and III chronic methodologies are incorporated into respective Phase II and III TIE manuals (U.S. EPA, 1993b, 1993c).

TIE methods should only be applied after toxicity has been observed in prior toxicity tests and should be applied to the same species showing the toxic response. To conduct TIEs in the most efficient and cost-effective manner possible, the approach should be outlined and discussed with the laboratory prior to initiation of a toxicity study. At a minimum the following items should be considered:

- Toxic signal – samples which demonstrate a high level of toxicity are preferable, since reduction of that toxicity after manipulation is easily measured and quantified. The level of toxicity required to trigger a TIE should be discussed with the laboratory (e.g. TIEs will only be performed on tests where a 50% reduction from the control is observed).

- Loss of toxicity – TIEs require that toxicity be present and that it not be rapidly degraded. For example, some samples demonstrate high initial toxicity which rapidly decays during storage thus preventing successful TIE characterization. This may especially be a concern for longer-term chronic effects, that is, if seven day tests are required for initial toxicity assessment and for toxicity evaluations and TIE manipulations, the toxicant must be more stable and persist longer in storage.

- Constituents of potential concern – if certain constituents are expected to be present at a given site this may help guide TIE efforts. For example, if high concentrations of metals are expected TIE manipulations specific to identifying the presence of metals can be performed in initial TIE efforts. Alternately, if certain constituents are not expected in stormwater samples it may be appropriate to develop an abbreviated subset of U.S. EPA procedures. For example, Phase I TIE procedures were designed for the characterization of municipal and industrial effluents and therefore include manipulations that target constituents expected in these types of effluents (e.g. ammonia, chlorine). These manipulations may not be appropriate for stormwater samples.

- Existing Data – Results of past TIEs conducted with stormwater samples may also help guide initial TIE efforts. Past investigations reviewed by Caltrans (Caltrans, 1999b) show that the toxicant groups that should be targeted in Phase I TIEs include volatile or oxidizable compounds, particulate-bound toxins, cationic metals, non-polar organics, and organophosphates.

Additional information on specific TIE manipulations is provided in Appendix A.

SECTION 5
SAMPLE COLLECTION METHODS AND EQUIPMENT

This section discusses the various methods and equipment that may be used for collection of samples for toxicity testing. This section is organized under the following subsections:

- **Sample Collection Methods**
- **Sample Collection Equipment**

Water quality in stormwater runoff may vary both laterally and vertically throughout the cross section of flow, and with time. For instance, floatable materials (oil, grease, light particles and debris, scum) may be present in significant amounts near the water surface, while heavier sediments are often concentrated near the bottom of the conveyance. Also, concentrations of some constituents may be higher in the first hour or two of runoff; this is often referred to as a "first flush" effect. During the course of a storm, rainfall intensity also may increase, raising runoff flow rates to the point where sediments are mobilized and scour occurs, resulting in temporarily higher concentrations of sediment-bound constituents.

Toxicity studies should be designed to ensure that collected samples are representative of runoff quality during the period of concern, based on the project objectives. For example, collection of samples to determine if runoff is toxic throughout an entire runoff event is best done by collection of flow-proportioned composite samples throughout the runoff hydrograph. See ***Appendix C*** in Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) for a discussion of flow-proportional compositing. Multiple grab samples may also be collected and combined into one composite sample for the same purpose. Studies may be designed to evaluate the toxicity of a specific part of the storm, this means collection of a discrete grab sample at a designated time during the storm. Finally, samples may be collected to determine if there is a change in toxicity over the hydrograph. This means collection and testing of multiple grab samples at key points throughout the hydrograph (at a minimum at first flush, during ascending limb, at peak flow, and during descending limb). Grab and composite sample collection methods and equipment are discussed below.

Flow measurement and precipitation measurement provide useful information to support stromwater runoff sample collection (e.g. flow measurement is necessary for accurate sample compositing and precipitation data can be used to understand site hydrology). Other important components of successful collection of stormwater runoff samples include system integration, system command/control, and remote communication. Each of these components are discussed in detail in Part I, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a). This section discusses the sample methods and equipment specific to collection of stormwater runoff samples for toxicity testing.

SAMPLE COLLECTION METHODS

Stormwater samples can be collected to represent a point in time (i.e., "grab" sample) or a period of time (i.e., "composite" sample). A grab sample is essentially a one-time collection of a sample volume adequate to perform the intended water quality analysis or toxicity tests. A composite sample is comprised of some number of individual sample aliquots mixed together. For stormwater monitoring, this usually refers to samples collected sequentially over time during a stormwater runoff event.

Stormwater samples can be collected using either manual or automated means. Project designers should select the combination of sample types and techniques most suitable to the toxicity study objectives and available resources.

Both automated composite sampling and manual grab sampling are appropriate for toxicity sample collection, depending on the study objectives. The advantages and disadvantages of each sample collection method in terms of toxicity testing are provided in Table 5-1.

Table 5-1. Advantages and Disadvantages of Grab and Composite Samples

Sample Type	Advantages	Disadvantages
Grab	▪ Easy to collect; requires a minimum of equipment. ▪ Provide a measure of instantaneous toxicity. Toxicity spikes are not masked by dilution.	▪ The chances of detecting a spike in toxicity would depend on the timing and frequency of sampling; the probability of missing toxicity spikes is high.
Composite	▪ The sample is collected over a longer period of time than grab samples and may contain toxicity spikes. ▪ Can provide a measure of toxicity throughout the event.	▪ Automated sampling equipment is sophisticated and expensive. ▪ Toxicity spikes may not be detected because they may be masked by dilution with less toxic runoff.

Composite Sampling

Automated sampling generally is the most cost-effective method of composite sample collection, and is particularly appropriate for large-scale programs (e.g., where a large number of sampling sites are monitored, or numerous sampling events are conducted over multiple years).

Automated monitoring systems are comprised of electromechanical devices that can be operated automatically (i.e., an on-site operator may not be needed). Automated sample collection is recommended for the following reasons:

- On-site time requirements by personnel are reduced during sample collection; therefore, the threat to worker safety by hazardous conditions (e.g., traffic, inadequate oxygen, toxic or explosive gases) is decreased.

- Automatic samplers can be programmed so that sampling operations are initiated when pre-determined conditions are met, such as a specific flow rate, flow depth, or rainfall amount. This reduces the possibility of missing the early stages of runoff.
- Automated equipment can be programmed in conjunction with a flow meter to collect flow-weighted composite samples, using a constant volume proportional flow method (see ***Appendix C*** in Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a)). This permits collection of representative samples throughout the storm event.

Composite samples also may be collected using manual methods. This approach may be warranted when the toxicity study is designed to evaluate toxicity at certain points of the storm or where the installation of automated sampling equipment is economically or logistically infeasible, or is not capable of providing the required sample volume. Although manual composite sample collection is more labor-intensive during a storm event, it will reduce required station setup and maintenance prior to each storm event. See ***Section 7*** for a description of manual compositing techniques.

Grab Sample Collection

A grab sample is an individual sample collected at one specific site at one point in time. Analysis of a grab sample provides a "snapshot" of stormwater quality. Grab samples are most often collected using manual methods and equipment (e.g. bailers, grab poles, etc.). Grab samples for toxicity testing can be collected directly into the bottle that will be used in the laboratory or an intermediate container may be used to fill the sample bottle (e.g. plastic cubitainers are most easily filled by collecting the samples in a glass amber bottle and pouring from this into the cubitainer). Grab sample containers must be filled to the top, leaving no head space to minimize the loss of toxicity due to volatilization of toxic constituents. See ***Section 9*** for additional information on sample container types.

SAMPLE COLLECTION EQUIPMENT

For all collection efforts, sampling devices must be made of chemical-resistant materials that will not affect the quality of the stormwater sample. In general, suitable sampling devices should be constructed of one of three materials: Teflon, glass, or polyethylene. These materials are known to be the most inert in terms of adsorption or desorption of organic and inorganic compounds. It is important to evaluate each component of the sampling device (e.g., bottle lids, connections, tubing) for possible sources of sample contamination. For example, latex and neoprene rubber tubings should be avoided because latex is organic and neoprene rubber may contain trace metals. Butyl rubber seals may also contribute organics to the sample.

Equipment that is constructed of stainless steel, such as dippers or sample intake strainers, may be Teflon-coated to make them suitable for use in collection of stormwater samples for toxicity testing.

Selection of Sample Bottle Type

Selection of the most appropriate sample container will depend upon study objectives (i.e. inclusion of TIEs), sampling logistics, and what is know about possible toxic constituents at each site. For toxicity testing both polyethylene "cubitainers" and borosilicate glass bottles have been used for sample collection. Selection of the most appropriate sample container will depend upon the following:

- Study objectives (i.e. inclusion of TIEs),
- Sampling logistics,
- What is known about possible toxic constituents at each site.

U.S. EPA recommends glass containers rather than plastic when TIEs are planned. U.S. EPA has reported that for some samples, toxicity was greater and was retained longer in samples collected and stored in glass bottles. This effect was attributed to adsorption of certain types of toxicants (e.g. surfactants, organophosphate insecticides) to polyethylene containers (U.S. EPA, 1991)).

Logistically, use of glass bottles creates some difficulty as transportation of large sample volumes in glass containers requires extra care (i.e. field crews must ensure that samples are packed effectively to prevent breakage during shipment to the laboratory).

If information is available regarding the targeted constituents at a given site, this should guide the selection of sample containers. For example, if metals are suspect toxicants it is more appropriate to collect samples in polyethylene containers. At sites where organics are of concern, glass is preferred over polyethylene. The use of polyethylene containers for toxicity samples has been shown to reduce toxicity when cationic polymers are present (i.e. the charged surface of plastic containers reduced toxicity). Polycarbonate has been identified as an alterative to polyethylene because it is less reactive to organics. Selection of appropriate sample containers for a given toxicity study should be evaluated and discussed with the laboratory prior to initiation of the study.

Automated Sampling Equipment

The key elements of an automated monitoring system that are required to collect flow-proportioned composite samples include:

<u>Sample Collection</u>:

- An automatic sampler,
- Sample intake tubing and strainer, and
- Sample bottle(s).

Flow Measurement:

- A flow measurement device,
- Flow sensor and cable, and
- Optional rain gauge.

Data Recording/Retrieval:

- A data storage device,
- System software,
- Optional remote communications capabilities, and
- Optional secondary/back-up power source.

These components are discussed in detail in the Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a).

Key components required for automated sample collection include an automatic sampler, tubing with strainer, and sample bottle(s); these components are further described below.

Automatic Sampler

Automatic samplers are comprised of a peristaltic pump, pump control electronics, a sample distribution system, a power supply, and a housing that contains the composite bottle(s). A peristaltic pump creates suction by compressing a flexible tube with a rotating roller, drawing a sample that is then pushed out of the pump. The pump operates best when placed close to the sample source; this reduces the suction head or lift (experience has shown that the reliability of peristaltic pumps drawing a consistent sample volume is greatly reduced as the static suction head increases). According to manufacturer's specifications, vertical lift must be no greater than 26 feet. When sampling with an automated sampler, static head height refers to the vertical distance from the surface of the flow stream to the automatic sampler pump inlet.

Automatic samplers may be configured for single or multiple bottle composite collection. Samplers configured to fill multiple sample bottles have a sample distribution mechanism. Tubing from the discharge port of the intake pump is connected to a rotating distributor arm that dispenses the samples into several sample bottles.

If flow-weighted sampling is planned, the automatic sampler must be capable of accepting a signal from a flow meter that is used to trigger collection of a sample aliquot. Cables can be purchased that connect each type of flow meter to an automated sampler. Additional details concerning automatic samplers are provided in the Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a)

Sampler Intake Strainer, Intake Tubing and Flexible Pump Tubing

The intake strainer is attached to the intake tubing and mounted to the bottom of a pipe or channel. Intake strainers prevent rocks and debris from clogging or damaging the intake tubing or pump. Sizes vary, but smaller intake strainers are generally better for use under low flow conditions. Sample intake strainers are typically made of stainless steel, or a combination of stainless steel and Teflon. For collection of samples for toxicity testing, all intake strainer parts must be Teflon, or coated with Teflon or Teflon-like material. Specific intake and pump tubing requirements and guidance on intake strainer placement is presented in Part I, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a).

Sample Bottle(s)

Automatic samplers may be configured to have a variety of sample bottles, from one to a dozen or more sample bottles. If a sampler holds a single bottle, all of the sample aliquots are pumped into this bottle, resulting in one large composite sample. Use of a single composite bottle does not allow for isolation of specific samples or groups of samples from specific periods of the runoff hydrograph, and provides less visual indication of sampler malfunction (if this should occur). A multiple bottle configuration, however, provides these capabilities.

It is important to keep extra bottles (for either the single or multiple bottle configuration) available in case bottles are contaminated or damaged, or in the event that bottles need to be changed to accommodate a larger-than-expected storm. If a storm delivers more precipitation than expected, sample bottles will fill prior to the end of the storm, prompting sample bottle replacement. Additional bottles may also be needed when large volumes of sample are required by the toxicity tests type selected.

In-situ Analytical Measurement Equipment

Certain conventional water quality parameters, including temperature, pH, electrical conductivity, and dissolved oxygen, should be measured in the field at the time of sample collection to provide basic indicators of the quality of the sample and to provide information to assess changes between time of collection and test initiation (see ***Section 4***). Electronic equipment is available to measure these parameters. Electronic sensors and data loggers may allow for near-continuous measurements of indicator parameters at reasonable cost. This equipment also makes it feasible to monitor every storm that occurs over a period of time, including short-duration events that would otherwise be impractical to monitor. In addition, data reduction and evaluation are simplified because the water quality results are simply downloaded from the data logger onto a laptop computer or a personal computer with a modem. However, it is important to realize the limitations associated with the use of sensors and data loggers:

- Sensors are only available to measure a limited number of parameters.

- The ion-specific sensors now available may not provide low enough detection limits to meet monitoring project DQOs.
- It may be difficult to assure the quality (i.e., precision & accuracy) and reliability of the results.
- Laboratory analysis is required in conjunction with the results to allow correlations to be made between the indicator readings and concentrations of specific constituents of concern.
- It may not be possible to reliably correlate a sensor-measured "indicator" parameter with a given constituent of concern.
- Sensors are subject to fouling or clogging from debris, algae, oil & grease, etc.
- Some sensors (e.g., turbidity) may require substantial flow for accurate readings.
- Sensors require routine maintenance to ensure proper function.
- Some sensors (e.g., pH, DO, conductivity) cannot be allowed to dry out; this is problematic in many drainage conveyances.

Manual Sampling Equipment

At some sampling locations it may be necessary to use manual sample collection equipment. Manual equipment can include hand-operated items such as bailers, grab poles, pitchers, or other items designed to lower an appropriate sample container into the runoff flow. This equipment is relatively inexpensive and easy to maintain. Additional information concerning manual sample collection and equipment in provided in ***Section 7***.

SECTION 6
SAMPLING AND ANALYSIS PLAN (SAP)

Proper documentation is required for all Caltrans toxicity studies. A stormwater SAP and Health and Safety Plan (HSP) should be prepared prior to initiation of any sampling activities.

This section provides general guidance for preparation of practical, useable SAPs for stormwater monitoring programs for toxicity testing. See ***Appendix D*** in Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) for detailed information regarding individual components to be included in the HSP.

The following are sections that should be included in a SAP:

- **Project Overview/Description**
- **Sampling Site(s)**
- **Toxicity Tests to be Conducted**
- **Data Quality Objectives (DQOs)**
- **Monitoring Preparation and Logistics**
- **Sample Collection, Preservation, and Delivery**
- **Quality Assurance/Quality Control**
- **Laboratory Sample Preparation and Analytical Methods**
- **Data Management and Reporting Procedures**

Appendix:

- **Health and Safety Plan (HSP)**

Inclusion of these sections will ensure development of a useable and practical SAP. The final product should be a single bound document that can be easily referenced during monitoring activities. This can be conveniently done by including the HSP as an appendix to the SAP. Printing the SAP/HSP on waterproof paper will reduce the potential for water damage to the document during field use.

All Caltrans stormwater monitoring documentation must be assigned a document identification number prior to document completion. The document identification number, assigned by the Stormwater Management Program document distribution system manager, is used to track the document and develop document distribution lists. Two weeks prior to expected document deliverable date, the author must contact the Caltrans stormwater management program document distribution system manager to receive a document identification number and mailing labels.

The SAP should be prepared by someone with a good understanding of field sampling procedures, laboratory testing methods, and data validation procedures. The toxicity laboratory should provide input to ensure that the SAP (especially the QA/QC portion) is realistic, and consistent with the laboratory's operating procedures. Field personnel should also provide input regarding logistical details, and ensure that the plan is practical and easy to use.

The SAP should include a thorough description of all activities required to implement the toxicity study. The plan should be organized to provide an overview of the project goals and organization, followed by a description of all monitoring activities in the chronological sequence in which they will typically occur. The plan should specify the quality assurance/quality control protocols that will be followed by field and laboratory personnel, and how the field and laboratory results will be managed and reported.

The contents of a typical stormwater SAP are shown in Figure 6-1.

1.0 PROJECT OVERVIEW/DESCRIPTION
- 1.1 Description of why the project is being conducted
- 1.2 Description of who is conducting the project
- 1.3 General scope of monitoring activities
- 1.4 Project organization/roles and responsibilities

2.0 SAMPLING SITE(S)
- 2.1 Site location (map) including Global Positioning System (GPS) coordinates
- 2.2 Written driving directions
- 2.3 Site access instructions (gates, locks, keys, combinations)
- 2.4 Notification procedures

3.0 TOXICITY TESTING TYPES
- 3.1 Identification of Methods (include SOPs for each)

4.0 DATA QUALITY OBJECTIVES (DQOs)
- 4.1 Analytical reporting limits
- 4.2 Analytical precision, accuracy, and completeness
- 4.3 Data Quality Evaluation Plan

5.0 FIELD EQUPMENT MAINTENANCE
- 5.1 Equipment calibration
- 5.2 Equipment maintenance
- 5.3 Equipment cleaning (bottles/lids/tubing)

6.0 MONITORING PREPARATION AND LOGISTICS
- 6.1 Weather tracking
- 6.2 Storm selection criteria
- 6.3 Storm action levels
- 6.4 Communications/notification procedures
- 6.5 Sample bottle order
- 6.6 Sample bottle labeling
- 6.7 Field equipment preparation

7.0 SAMPLE COLLECTION, PRESERVATION, AND DELIVERY
- 7.1 Sample collection methods
- 7.2 Field measurement methods
- 7.3 Field equipment list
- 7.4 Sample containers, preservation, and handling
- 7.5 QA/QC sample collection methods
- 7.6 Sample labeling (site names/codes, etc.)
- 7.7 Composite sample splitting
- 7.8 Forms and procedures for documenting sample collection and field measurements
- 7.9 Laboratory communication procedures
- 7.10 Sample shipping/delivery, chain-of-custody

8.0 QUALITY ASSURANCE/QUALITY CONTROL
Field procedures for QA/QC sample collection

9.0 LABORATORY SAMPLE PREPARATION AND ANALYTICAL METHODS
- 9.1 Laboratory sample preparation procedures
- 9.2 Toxicity Testing Methods (including testing methods, sample handling, and holding times)

10.0 DATA MANAGEMENT AND REPORTING PROCEDURES
- 10.1 Data validation
- 10.2 Electronic data transfer
- 10.3 Filing of electronic and hard copy data
- 10.4 Reports

APPENDIX
A Health and Safety Plan

Figure 6-1. A Typical Stormwater Sampling and Analysis Plan Outline

The following sub-sections further describe the contents of a typical stormwater SAP that is applicable for toxicity studies.

OVERVIEW: PROJECT DESCRIPTION, ORGANIZATION, AND RESPONSIBILIES

This section of the SAP should briefly describe:

- Description of why the toxicity study is being conducted,
- Description of who is conducting the study,
- General scope of toxicity monitoring activities, and
- Roles and responsibilities of the key field and laboratory personnel who will be involved in the study (typical roles include project manager, sampling coordinator, sampling team leaders, field crew, project QA/QC officer, and laboratory QA/QC manager).

SAMPLING SITES

This section should describe the sampling sites selected for the toxicity study and provide rationale for the inclusion of a site. Site selection for toxicity studies should focus on existing Caltrans stormwater monitoring sites which were selected based upon representativeness of land uses in the area, achievable flow measurement, site access, personnel safety, equipment security, and availability of electrical power and telephone. See ***Section 3*** for monitoring site selection guidance.

The following detailed information should be included for each monitoring site:

- Site location map,
- GPS coordinates,
- Written driving directions,
- Site access instructions (locked gate keys or combinations), and
- Notification procedures (if notification is required prior to site access).

TOXICITY TEST METHODS

This section should specify the types of toxicity tests to be conducted to meet program objectives. See ***Section 4*** for toxicity test type selection guidance. The SAP should include a list of test types, in tabular form, that includes at a minimum the following columns:

- Species to be tested,
- Test duration (specify acute or chronic),
- Exposure concentrations,
- Sample collection method (i.e. grab or composite),
- Bottle type,
- Volume required,
- Preservation, and
- Laboratory performing testing.

U.S. EPA methods (1993a, 1994) provide summaries of test conditions for each toxicity test method, these protocols should be included in this section (see ***Section 9***).

DATA QUALITY OBJECTIVES (DQOs)

This section should specify the project goals and objectives, key project parameters, and the DQOs that were deemed appropriate for the project. See ***Section 2*** for guidance on the development of DQOs. DQOs should be outlined in a Data Quality Evaluation Plan (DQEP). The DQEP should also describe the process by which data produced by the study are evaluated to provide a reference point from which a program-consistent QA/QC evaluation can be performed (see ***Section 8***).

FIELD EQUIPMENT MAINTENANCE

This section should include specific information concerning the maintenance of all sampling equipment. At a minimum, all equipment should be maintained according to manufacturer specifications. The following is a list of items that typically require regular maintenance:

- Automatic sampler – calibrate, check battery and check/replace desiccant,
- Intake tubing/strainer - inspect & clear or replace,
- Flow measuring device - calibrate, check battery and check/replace desiccant,
- Rain gauge - calibrate and check for debris, and
- Portable field instruments (e.g. pH meter) – calibrate.

Bottle and equipment cleaning should also be covered in this section of the SAP (see ***Appendix E*** in Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) for guidance on sample bottle and equipment cleaning procedures). In addition, if equipment is located in a confined space, this section should include a discussion on the acceptable confined space entry procedures. See ***Section 5*** and Part I, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) for guidance on the selection of sampling methods and equipment and detailed equipment installation and maintenance guidance.

MONITORING PREPARATION AND LOGISTICS

This section should describe the necessary pre-storm preparations including:

- Weather tracking
  -Procedures
  -Responsibilities
  -Obtaining quantity of precipitation forecast (QPF)
- Storm selection criteria
  -Stage of wet season
  -Antecedent conditions
  -Storm duration
  -Recommended minimum storm size
  -Logistical constraints

- Storm action levels
  - *-Non-monitoring*
  - *-Standby*
  - *-Pre-alert*
  - *-Alert*
  - *-Go*
  - *-Post-storm*

- Communication/notification Procedures
  - *-Telephone tree*

- Sample bottle order

- Sample bottle labeling

- Field equipment preparation
  - *-Inspect*
  - *-Calibrate*
  - *-Charge batteries*
  - *-Check/replace desiccant*

See Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) for monitoring preparation and logistics guidance.

SAMPLE COLLECTION, PRESERVATION, AND DELIVERY

This section should provide detailed guidance on standard operating procedures for field personnel (i.e., a concise, useable guide for sampling activities). At a minimum, this section should include:

- Description of clean sample handling techniques,
- Sample collection methods to be used at each location,
- Field measurement equipment (e.g., pH meter) and methods to be used at each location,
- Field equipment that will be required for monitoring at each station (includes a checklist so field people can ensure they have everything they will need before proceeding to the sampling location),
- Sample labeling procedures (site name/code, sample date and time, etc.),
- Sample compositing and splitting procedures (including testing prioritization for instances of insufficient sample volume),

- Procedures for collecting and labeling field blanks and duplicate samples,
- Forms and procedures for documenting sample collection and field measurements,
- Sample preservation and handling procedures,
- Laboratory communication procedures, points of contact, and phone numbers,
- Procedure for sample shipment or delivery to laboratory, and
- Details on completing chain-of-custody forms.

See ***Section 7*** for detailed sample collection, preservation, and delivery guidance.

QUALITY ASSURANCE/QUALITY CONTROL

The QA/QC section should focus on QA/QC procedures necessary for field activities, such as field procedures and collection frequencies for the following:

- Laboratory duplicates
- Field blanks
- Equipment blanks

QA/QC sample collection frequencies are best presented in a QA/QC sample collection schedule table with a column for each event and a row for each site.

Laboratory QA/QC should be discussed in an appendix and should include the frequency and type of laboratory QA samples (e.g., laboratory duplicates, split samples, and reference toxicant tests), data reporting requirements (electronic and hard copy) and corrective actions. See ***Section 8*** for detailed QA/QC guidance.

LABORATORY SAMPLE PREPARATION AND TEST METHODS

This section should describe the activities to be conducted by the toxicity laboratory, including sample preparation procedures. A table containing the following information should be presented:

- Species to be tested,
- Test duration,
- Holding time,
- Test acceptability criteria, and
- Laboratory QA/QC

See ***Section 9*** for laboratory sample preparation and toxicity test methods guidance.

DATA MANAGEMENT AND REPORTING PROCEDURES

This section should describe how the data generated from the laboratory and field measurements are to be handled, evaluated, and reported. It should address:

- Data validation (QA/QC review in light of project DQOs, per procedures specified in the DQEP),
- Electronic data transfer,
- Filing of electronic and hard copy data,
- Data analysis (e.g., statistical evaluation, etc.), and
- Reports (e.g., quarterly, annual, end of project).

At the beginning of the project, the field and laboratory personnel should review the entire SAP to obtain an overview of their respective roles and responsibilities. Before each sampling event, the field personnel should review the sampling methods section in detail, and the laboratory personnel should review the laboratory sample preparation and methods section. See ***Section 8*** for QA/QC data evaluation guidance.

Efficient data storage, retrieval, and transfer methods should be established prior to initiation of any monitoring activities, including those to support toxicity studies. Suggestions are provided in the Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) to guide Caltrans contractors and district personnel in the development of a reliable and useful data management system. Data gathered during toxicity studies will be incorporated into the Caltrans Statewide Stormwater Quality Database. Specific data reporting protocols for toxicity results are outline in ***Section 10***.

HEALTH AND SAFETY PLAN

Stormwater monitoring involves activities that have the potential to adversely affect the health and safety of field personnel. Stormwater monitoring field crews often work in wet, poor-visibility conditions. Sampling sites may be located along streets or stream channels, or in remote, poorly-lit areas, and may require access on a 24-hour basis. Workers may be exposed to traffic hazards, confined spaces, biological hazards, hazardous materials, fast-moving storm waters, and slippery conditions. Besides monitoring activities during storm events, monitoring equipment installation and maintenance activities may also take place under these conditions.

The information contained herein is for guidance only, and does not supersede or otherwise change any applicable state, local, or agency health and safety requirements or programs.

The general steps in HSP development for a given stormwater monitoring project are listed below:

- Assign a health and safety officer to oversee all health and safety activities.
- Write concise descriptions of all of the field activities that will be included in the program.
- Identify and evaluate the potential physical, chemical, and biological hazards associated with each activity.
- Specify the measures to be employed to reduce the health and safety risks associated with the identified hazards (i.e., precautions).
- Specify health and safety training and documentation requirements.
- Develop an emergency response/contingency plan.

Each of these steps is described in ***Appendix D*** of the Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a). Figure 6-2 contains an example outline for a project-specific HSP.

1.0 Introduction

2.0 Project And Safety Personnel

3.0 Site Information

4.0 Work Activities Covered By Health And Safety Plan

5.0 Hazard Assessment
- 5.1 Chemical Hazards
- 5.2 Confined Spaces
- 5.3 Physical Hazards
- 5.4 Biological Hazards

6.0 General Health And Safety Requirements
- 6.1 Employee Clearance
- 6.2 Site Safety Meetings
- 6.3 Accident Reporting
- 6.4 Prohibited On-Site Activities
- 6.5 Communications

7.0 Site-Specific Health And Safety Requirements
- 7.1 Special Medical Tests
- 7.2 Special Training
- 7.3 Physical Hazards
- 7.4 Hazardous Materials Identification And Protection
- 7.5 Confined Space Entry
- 7.6 Traffic Control
- 7.7 Personal Protective Equipment
- 7.8 Site Illumination
- 7.9 Biological Hazard

8.0 Emergency Response Procedures
- 8.1 Hospital Information
- 8.2 Emergency Route to Hospital
- 8.3 First Aid & Related Equipment

Figure 6-2. A Typical Health and Safety Plan Outline

SECTION 7
SAMPLE COLLECTION

Equipment and bottles used in the collection of stormwater samples for toxicity testing must be handled with great care to minimize the possibility of contamination. The ease with which stormwater samples can be unintentionally contaminated cannot be overemphasized. Samples collected for toxicity testing must also be handled properly to avoid possible changes in the toxicity of the sample (e.g. loss of volatile organic compounds). The following procedures include sample collection and handling techniques that maximize the ability of sampling personnel to collect samples reliably and with minimal sample contamination or loss of toxicity.

The following are basic sample collection and handling elements required during collection of stormwater samples for toxicity testing:

- **Personnel Safety**
- **Sampling Equipment and Bottles**
- **Clean Sampling Techniques**
- **Grab Sample Collection**
- **Composite Sample Collection**
- **Flow Monitoring**
- **Composite Bottle Changing**
- **Field Measurements**
- **Sample Representativeness Evaluation**
- **Multi-bottle Compositing and Composite Sample Splitting**
- **Sample Preservation and Holding Time**
- **Sample Delivery/Chain of Custody**

These elements are described below to provide sample collection and handling guidance for field personnel engaged in stormwater monitoring.

PERSONNEL SAFETY

Before samples are collected, personnel must ensure the safety of such activities at each sampling location. As discussed in Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a), personnel safety should be considered when selecting monitoring sites. Adherence to the following recommendations will minimize risks to sampling personnel:

- At no time during storm conditions or when significant flows are present should sampling personnel enter a manhole or standpipe.
- Two-person field crews should be available for all field work to be conducted under adverse weather conditions, or whenever there are risks to personal safety.
- Use of automated samplers can eliminate many of the hazards associated with manual sample collection, as personnel may not be required to be at the site for composite sampling.
- Personnel must be trained regarding appropriate traffic control measures. If appropriate, a traffic control plan should be developed for each site and included in the sampling plan and analysis plan prior to conducting sampling events.
- Only personnel properly trained and equipped for confined space entry may conduct a "confined" space entry; this applies to both the entrant and the observers.
- When appropriate, an encroachment permit must be filed with the local Caltrans district.

SAMPLING EQUIPMENT AND BOTTLES

For toxicity studies, field personnel may be required to collect composite samples and/or grab samples. It is important to use the appropriate sample bottles and equipment for collection of toxicity samples (see ***Section 5***). Improper bottles and equipment can introduce contaminants and cause other errors which can invalidate the data. For example, chemicals may leach from the bottle into the sample, or waterborne constituents may adsorb to sampling equipment or to the sides of the bottle.

Sample Bottles

Polyethylene "cubitainers" or borosilicate glass bottles may be appropriate for toxicity samples, depending on the objectives of the study, sampling logistics, and what is known about possible toxic constituents at each site (see ***Section 5***). The selection of the appropriate sample bottle type should be discussed with the laboratory prior to initiation of the study. Refer to Table 9-1 in ***Section 9*** for additional information.

Equipment and Bottle Cleaning and Handling

Before samples are collected, all sampling equipment and bottles are cleaned in a laboratory using appropriate solvent rinses, deionized water and/or other methods (high temperatures). The laboratory is responsible for generating acceptable equipment blanks and sample bottle blanks to demonstrate that the sampling equipment and bottles are free from trace metals and organics contamination before they are delivered to field sampling personnel. An acceptable blank is one that is free from toxicity. ***Section 8*** provides additional information on collection of equipment blanks.

New plasticware used for sample collection or organism exposure vessels does not require thorough cleaning before use. New sample containers should be rinsed before use according to the protocol outlined in the bottle rinsing and labeling section below.

New glassware must be soaked overnight in 10% acid and rinsed well in deionized water and dilution water. All non-disposable sample containers, test vessels, tanks, and other equipment that have come in contact with effluent must be washed after use to remove contaminants as described below:

1. Soak 15 min in tap water and scrub with detergent, or clean in an automatic dishwasher.
2. Rinse twice with tap water.
3. Carefully rinse once with fresh, dilute (10%, V:V) hydrochloric or nitric acid to remove scale, metals and bases. To prepare a 10% solution of acid, add 10 mL of concentrated acid to 90 mL of deionized water.
4. Rinse twice with deionized water.
5. Rinse once with full-strength, pesticide-grade acetone to remove organic compounds (use a fume hood or canopy).
6. Rinse three times with deionized water.

After cleaning, sample bottles and laboratory-cleaned sampling equipment are handled only while wearing clean, powder-free nitrile gloves. All laboratory-cleaned sampling equipment is double bagged in clean zip-lock plastic bags for storage or shipment. Clean bottles are stored in a clean area with lids properly secured.

Bottle Labeling and Rinsing

Immediately prior to rinsing sample bottles, the bottle labels should be checked, and date and time added using a waterproof pen. Attempting to label grab sample bottles after sample rinsing and/or collection may be difficult because of wet labels.

Before stormwater samples are collected for toxicity testing, each sample bottle must be rinsed with site water according to the following procedure:

- Rinse every sample bottle **three** times with site water.
- For containers smaller than 1-liter, rinse each container by filling it with site water three times.
- For containers 1-liter and larger, fill one container with site water and use it to pour a little water into each of the other containers.
- If samples are poured from larger composite bottles, site water from the composite sample should be used for rinsing prior to filling the sample bottle.

- When rinsing each container be sure the cap is on the bottle so that the cap gets rinsed as well.

CLEAN SAMPLING TECHNIQUES

Caltrans stormwater monitoring projects employ "clean" sampling techniques to minimize potential sources of sample contamination, particularly from trace pollutants. Experience has shown that when clean sampling techniques are used, detected concentrations of constituents tend to be lower. Clean sampling techniques are especially important for toxicity analysis because tests are sensitive to the combined effect of all constituents in the sample. As a result, unmeasured and unidentified compounds that would not interfere with chemical analysis may interfere with toxicity tests. Clean sample collection techniques that should be followed during the collection of stormwater samples for toxicity testing are described below. More extensive clean sampling techniques may be required under certain conditions, such as monitoring to assess receiving water impacts.

Extreme care must be taken during all sampling operations to minimize exposure of the samples to human, atmospheric, and other potential sources of contamination. Care must be taken to avoid contamination whenever handling bottles, lids, sample tubing, and strainers. Whenever possible, grab samples should be collected by opening, filling and capping the sample bottle while submerged, to minimize exposure to airborne particulate matter. Bottles should be completely filled, leaving no head space. Additionally, whenever possible, samples should be collected upstream and upwind of sampling personnel to minimize introduction of contaminants.

To reduce potential contamination, sample collection personnel must adhere to the following rules while collecting stormwater samples:

- No smoking
- Always wear clean, powder-free, nitrile or similar surgical-quality gloves when handling sample containers.
- Never sample near a running vehicle. Do not park vehicles in immediate sample collection area (even non-running vehicles).
- Minimize the amount of time any sample container is left open.
- Do not set lids down where they may accumulate contaminants.
- Prevent foreign material (blowing dust, leaves, etc.) from entering any open sample container.
- Never touch the inside surfaces of sample bottles, lids, or composite carboys, even with gloved hands.
- Never touch the exposed end of a sampling tube.
- Avoid allowing rainwater to drip from rain gear into sample bottles.

- Do not eat or drink during sample collection.
- Do not breathe, sneeze or cough in the direction of an open sample bottle.

GRAB SAMPLE COLLECTION

Grab sampling may be required for certain toxicity studies (see ***Section 2***). Grab samples can be collected with or without the use of automated sampling equipment. Non-automated options include pumping the sample using a portable pump, direct submersion, or use of an intermediate container. When automated equipment is involved, the equipment can be paused to allow for grab sample collection. Each of these methods are discussed below.

Grab Sample Collection Without the Use of Automated Equipment

Grab samples can be collected by direct submersion of each individual sample container. In some instances it may not be possible to collect the sample directly into the sample container and an intermediate container will be required. When use of an intermediate container is appropriate, grab samples should be collected by holding an appropriate container (bailer, sample bottle, etc.) under the outfall of a discharge pipe, at the lip of an inlet grate, or by submerging a container in the discharge stream with the container opening facing upstream, depending on monitoring site configuration. The sample is then poured immediately into the appropriate grab sample bottle. Efforts should be made to collect samples without the use of intermediate containers. If unavoidable, ensure that intermediate containers are clean and are not used between sites (i.e. a clean container should be used at each sampling location where an intermediate container is necessary).

Grab samples also can be collected by pumping the sample into the appropriate sample container(s) using a portable peristaltic pump. First, clean tubing is installed into the pump. The intake end of the tubing is placed into the runoff stream at a point that is mid-stream and mid-depth. The output end of the tubing is held at the mouth of the appropriate sample container. Make sure that the tubing does not touch anything besides the sample container and the runoff. Completely fill sample containers so that there is no head space.

Grab Sample Collection Using Automated Equipment

At sites equipped with automated sampling equipment it is possible to use this equipment for grab sample collection. When automated equipment is programmed to collect composite samples and monitoring is in progress, sampling may be paused for grab sample collection. This is accomplished by pausing the sampler (see manufacturer's manual for instructions), and removing the pump tubing from the composite sample bottle using clean, powder-free gloves. Care should be used not to touch the end of the

tubing, even while wearing gloves. The tubing is then held at the mouth of the sample container(s) to be filled and the sampler is set to pump (see manufacturer's manual for instructions on starting the pump). Once sample container(s) are filled completely (leaving no head space), the tubing should be returned to its original position in the composite sample bottle and the sampler must be restarted (see manufacturer's manual) to return to automated composite sample collection. Clean handling techniques must be used when handling the pump tubing and sample bottle lids. When using this grab sample collection method, an effort should be made to collect the sample between collection of composite sample aliquots (i.e. immediately after the automated sampler has collected an aliquot). This will avoid or reduce disruption of composite sample aliquot collection timing.

COMPOSITE SAMPLE COLLECTION

A composite sample is made up of multiple sub-samples (aliquots) collected over some spatial or temporal range. Stormwater runoff composite samples are typically collected from a single location during a period of runoff. Such temporal composites can be collected on a time-proportioned basis (equal sample aliquot volumes collected at equal time intervals) or flow-proportioned basis (samples are collected either on an even-time-interval basis, with sample aliquot size proportional to instantaneous measured flow rate, or on an even-flow-interval basis, with a set aliquot volume collected at passage of each equal, pre-set flow volume). Because stormwater runoff flow typically varies throughout a storm event, flow-proportioned composite sampling is the standard composite sample collection method [see Part I, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a)] for guidance on the selection of sample collection methods and equipment). Composite samples are typically collected using automated sampling equipment, but can also be collected manually.

Flow-proportional sampling requires determination of several key parameters:

- Storm event quantity of precipitation forecast ("QPF"; from forecast information),
- Expected runoff volume (determined from the QPF and watershed characteristics),
- Expected storm duration (for even-time-interval methods),
- Minimum required composite sample volume for all planned toxicity tests (including TIEs) (see ***Section 9***) obtained from the contract toxicity laboratory,
- Minimum acceptable number of sample aliquots (see Table 7-1 and discussion below), and
- Sample aliquot size (varies proportional to measured flow throughout the event for even-time-interval methods, and set to a single volume per event for even-flow-volume methods)

See Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) for a detailed discussion of how to determine flow-proportioning parameters.

Automated Composite Sample Collection

Automated flow-proportional composite sampling is typically done on an even flow-volume-per-sample basis; that is, a sample aliquot of equal size is collected every time a pre-selected flow volume passes by the flow sensor. The flow volume per sample is determined based on the QPF and the required composite sample volume [see Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a)], with consideration of the minimum required number of sample aliquots for the storm event (see Table 7-1 and discussion below). At automated monitoring stations, sample collection will begin automatically once the programmed thresholds (triggers) have been met (see Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) for automated station programming and preparation).

Automatic sampling stations should be checked periodically throughout a monitored storm event to make sure the station is functioning properly. If the composite sample bottle (or bottles, in the case of multi-bottle composite sample collection) fills more rapidly than expected, field personnel should be mobilized to conduct a bottle change (bottle changing is described in detail later in this section). If the required sample volume exceeds the capacity of one bottle, this will also require a bottle change. If the composite sample collection period exceeds 24 hours, the composite sample bottle(s) should be replaced with (a) clean bottle(s) at or prior to the end of each 24-hour period. Because the sample holding time is short for toxicity tests (36 hours), composite sample volume should be removed from each 24-hour composite for testing to comply with holding time requirements.

After the storm event has ended, field personnel are mobilized to retrieve the full composite sample bottle(s) and interrogate sampling equipment. Sample splitting and delivery to the laboratory are described later in this section.

Manual Composite Sample Collection

Manual composite sample collection may be conducted at monitoring sites that are not equipped with automatic equipment. Manual composite sample collection can be done on a time-proportional compositing basis, but it is generally possible to perform flow-proportional manual composite sampling using one of the techniques described below. Manual flow-proportional composite sample collection is conducted using the same basic principals as automatic composite sample collection. When possible, ensure that sample containers are completely filled, leaving no head space. Typical manual composite sample collection methods are described below.

Flow-Proportioning – Even Time Interval Basis

This method involves the collection of sample aliquots at a specified time interval, with the aliquot volume set proportional to the measured flow rate. The sampling time interval is set to ensure collection of the minimum number of aliquots required for adequate storm representativeness (see discussion later in this section), based on the expected (forecast) storm duration. Sample aliquot volumes are set to ensure collection of the required composite volume over the course of the expected storm event, based on the storm QPF and the expected runoff volume (this requires some advance knowledge of rainfall/runoff relationships in the monitored watersheds; see Part I, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) for a discussion of the relevant calculations). At each sampling interval the flow rate is measured [using one of the methods described in Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a)] and a sample aliquot volume is collected in proportion to the measured flow prior to collection. Sample aliquots are composited to generate a single event composite sample. This method requires advance preparation of a table showing the aliquot volumes to collect for a range of expected flow rates, over a range of possible storm event QPFs. In this table, the aliquot volumes are set so as to ensure collection of the full composite sample volume required to perform all planned analyses for a given QPF.

Flow-Proportioning – Even Flow Volume Basis

This method is typically more difficult than the even-time-interval method described above, because it requires keeping a cumulative running tally of flow volume, which is not normally practical without automated flow monitoring equipment. As with automated composite sampling, flow volume per sample is calculated using the target storm QPF, with consideration for the required composite sample volume and the minimum acceptable number of aliquots, as discussed below (also see Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a) for guidance on calculating flow volume per sample). Once runoff begins, flow rate is measured periodically [using one of the methods described in Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a)], and sample aliquots are collected each time the pre-determined flow volume per sample has passed the sampling location. Instantaneous and cumulative flow volume can be calculated by inputting the flow data into a portable computer and applying Manning's equation or other appropriate flow equation in the field [see Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a)]. Sample aliquots are collected either as manual grabs or by using a peristaltic pump equipped with appropriate tubing and strainer [see Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a)]. Each sample aliquot collected is of equal volume (typically 250-1000 mL) and combined into a single composite bottle immediately after collection.

Flow-Proportioning Using Precipitation Measurement

For sites where flow measurement is extremely difficult (such as sites where sheet flow is prevalent) flow-proportional samples may be collected using precipitation measurements as an analog for runoff flow. The assumption is made that runoff volume is directly proportional to event precipitation. So, instead of calculating flow volume per sample, rainfall depth per sample is determined. A sample aliquot is then collected each time the selected precipitation increment has fallen. For this approach, an on-site rain gauge is required for precipitation measurement [see Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a)]. To determine appropriate rainfall amount per sample for a target storm event, simply divide the event QPF by the number of sample aliquots required (the number of sample aliquots required is determined by the total composite volume required and the desired sample aliquot volume, subject to the minimum numbers of sample aliquots per event, as discussed later in this section).

Multi-Bottle Flow-Proportioning

This method of flow-proportional sample collection involves collecting sample aliquots of equal volume at a predetermined time interval throughout the storm event, and recording the flow rate at the time of sample collection. The sample aliquot volume is set in advance, based on the expected duration of the storm and the required composite sample volume, and considering the minimum number of aliquots required (see discussion below). After the storm has ended, a portion of each aliquot is composited to generate a single flow-proportional composite sample. The volume used from each aliquot is directly proportional to the flow rate that was recorded during the aliquot collection. Using this method, the highest flow rate measured during the event is used to determine the scale for the sample volumes added to the composite from each aliquot. For example, for each aliquot, the flow reading taken during sample collection can be divided by the highest flow reading during the event, and that percentage is the percentage of the aliquot that is added to the composite. This method requires more bottles and bottle handling than the other methods described above. However, this method is commonly used due to its flexibility and relative ease in carrying out the procedures in the field.

FLOW MONITORING

Flow measurements are necessary to produce flow-weighted composite samples. Flow measurements should be performed utilizing one of the methods discussed in Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a). If using manual methods, field crews should begin taking flow measurements as soon as possible after stormwater runoff begins (concurrently with sample collection). If automated sampling equipment is utilized, the equipment must be programmed to obtain the desired composite sample volume every time a specified flow volume is recorded, based on the predicted rainfall amount. Methods for programming automatic samplers

and flow meters are described in Part I, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a).

If multiple bottles are used for composite sample collection, or if more flow volume is delivered than expected during a storm event, requiring one or more composite bottle changes per monitoring station, it is necessary to combine the multiple composite bottles to produce a single flow-weighted composite sample. To do this, it is normally necessary to use the collected flow data to determine the amount of sample from each composite bottle to be used to form the final composite. When using automated equipment, the field crew will typically download data from the flow meter or datalogger, to determine the flow volume represented by each composite bottle. The sample volumes to be used out of each composite bottle can be calculated by the monitoring crew, and the completed calculations faxed or otherwise delivered to the lab. The methods for calculating appropriate sample volumes from each bottle are described below under "Multi-bottle Compositing".

COMPOSITE BOTTLE CHANGING

If an automated monitoring station is used for the collection of composite stormwater samples and a composite bottle change is required, composite bottle changing is conducted using the steps listed below.

1. The automated sampling equipment is placed in pause mode prior to the initiation of a composite bottle change. This action is accomplished in the field or by remote monitoring personnel if the monitoring station is equipped with telemetry.
2. Field personnel should wear clean, powder-free nitrile gloves and practice clean sampling techniques (see above).
3. To change a sample bottle, the end of the pump tubing is removed from the full sample bottle, the full bottle is removed from the sampler and capped with a clean lid, a clean bottle is placed in the sampler, and the tubing end is placed into the clean bottle. Do not allow the exposed tubing end to contact hands or any other surface.
4. After the sample bottle has been changed, the sampler is closed and the sampler keypad is used to place the sampler in sampling mode. The field supervisor or remote operation personnel are notified as soon as the bottle change is complete.
5. The sampling team fills out the appropriate information on the label of the collected composite sample bottle(s).
6. The collected composite bottle(s) are surrounded with ice, and secured inside the vehicle for transport.
7. Verify that the automatic sampler has been placed in sampling mode, if sampling is to continue. Visually inspect the components for possible damage or clogging,

to be sure the system will be ready to continue sampling, or is ready to sample the next storm.

FIELD MEASUREMENTS

Field measurements, including pH, DO, temperature, and EC, should be taken at each site during sample collection (see ***Section 4***). Samples for field analysis should be collected using methods similar to grab sample collection. Collect samples by placing a sampling container directly into the runoff stream. Take measurements on the sample using appropriate meters, which should be calibrated according to manufacturer's standards prior to each targeted storm event, and record all measurements on the field log.

SAMPLE REPRESENTATIVENESS EVALUATION

Immediately following sample collection, composite sample representativeness must be evaluated to determine whether samples meet the project minimum acceptable storm capture parameters (number of aliquots and percent storm capture). Samples not meeting these criteria are generally not tested. However, the Caltrans Project Coordinator should be consulted to make the decision whether or not to analyze the samples.

Percent storm capture is the percentage of the total event flow that passes the sampling station during which sample collection occurred (i.e., the portion of the runoff represented by the composite sample). This is calculated simply by dividing the flow volume that passed the sampling station during sample collection by the total flow that passed the sampling station during the entire monitoring event.

The minimum acceptable number of sample aliquots and minimum acceptable storm percent capture depend on the total event precipitation, as shown in Table 7-1. The specified minimum number of sample aliquots is intended to ensure adequate representativeness of the composite sample throughout the monitoring event. Higher numbers of sample aliquots are desirable whenever possible, subject to the practical limitations of sample collection.

Table 7-1. Monitoring Event Representativeness Requirements

Total Event Precipitation	*Minimum Acceptable Number of Aliquots*	*Percent Capture Requirement*
0-0.25”	6	85
0.25-0.5”	8	80
0.5-1”	10	80
>1”	12	75

MULTI-BOTTLE COMPOSITING AND COMPOSITE SAMPLE SPLITTING

Procedures for combining multiple composite samples to produce a single sample, and the procedures for splitting samples into multiple sample bottles are described below.

Multi-bottle Compositing

When multiple composite sample bottles are filled at a single site during a single storm monitoring event, the sample bottles are typically composited together to produce a single composite sample representing the entire monitoring event.

To combine multiple sample bottles to generate a single representative composite sample, the following two items must be determined: 1) the percent of the sampling event flow represented by each individual sample bottle, and 2) which of the sample bottle(s), if any, will limit the compositing of samples. Because individual sample bottles will likely contain different volumes, one bottle will likely dictate the total available sample volume. Individual sample bottles may contain different sample volumes for several reasons. For example, the number of aliquots may differ in each bottle if runoff ceased before triggering all programmed sample aliquots. Composite bottle volumes may also differ due to unequal collection of aliquot volumes, sometimes caused by pump tubing blockages or wear.

Each individual composite sample bottle corresponds to the volume of stormwater runoff that passed the sampling point during the collection of that composite sample. Composite samples are mixed in relative proportion, according to the percentage of total volume that passed the sampling point during the storm event. Therefore, to properly combine multiple composite samples, the following must be known:

- Individual sample volumes in each sample bottle.
- Total runoff flow volume that passed during the collection of each individual sample bottle.
- The total runoff volume for the monitoring event.

Multiple composite samples should be combined using the following formulas:

$V_n/V_t = P_n$, and

$S_t * P_n = S_n$

Where;

V_n = the volume of flow that passed during the collection of bottle n
V_t = the total volume of flow that passed during the sample collection event
P_n = the percent of the total sampled flow represented by bottle n
S_t = the total volume of sample collected in all bottles combined
S_n = the volume of sample contributed from bottle n toward the combined composite sample

The following is an example of how multiple composite samples are combined:

Bottle #1 = 8 L of sample 10,000 CF passed during the collection of bottle #1 (V_1)

Bottle #2 = 10 L of sample 15,000 CF passed during the collection of bottle #2 (V_2)

Total volume passed during sample collection = 25,000 CF (V_t)

Total composite sample collected = 18 liters (S_t)

Bottle #1, % of total flow = % of composite = 10,000/25,000 = 40% (P_1)

Bottle #2, % of total flow = % of composite = 15,000/25,000 = 60% (P_2)

Therefore, the single composite is made up of 40% from bottle #1 and 60% from bottle #2. Since 40% of the total sample volume collected (18 liters) equals 7.2 (S_1) liters and 60% equals 10.8 liters (S_2), it is apparent that bottle #2 has limited sample volume for compositing. Therefore, the entire 10 liters of sample from bottle #2 is mixed with the following volume (X) from bottle #1.

10 liters/60% = X liters/40%

X (the volume required from bottle #1) = 6.7 liters

The two composite samples are combined by adding 6.7 liters from sample bottle #1 to 10 liters from sample bottle #2.

Each sample bottle must be well-mixed prior to pouring off into another composite bottle. The sample is mixed thoroughly by shaking or otherwise agitating the composite bottle to prevent sediment from remaining on the bottom of the bottle. Throughout the sample compositing procedures, clean, powder-free nitrile gloves are used for bottle and lid handling. This process can be done by analytical laboratory personnel, or by field sampling personnel in a clean, dry setting.

Composite Sample Splitting

Composite samples collected in a single composite sample bottle are poured, by the laboratory or the sampling team, into individual sample bottles for analysis (to limit contamination it is recommended that splitting be conducted by the laboratory). When toxicity testing is planned in conjunction with general stormwater monitoring, toxicity testing can be viewed by the sampling crew as an additional "constituent" for analysis. Therefore, samples for toxicity testing should be poured off into the appropriate sample containers in the same manner as samples for other analyses. When pouring off samples for toxicity testing, fill sample containers completely leaving no head space. When a composite sample duplicate is required, the sampling team will be required to split the composite sample into two composite bottles to generate a subsampling duplicate. As with field duplicate samples (replicate samples collected simultaneously in the field), subsampling duplicates (replicate samples generated from a single composite sample bottle) should be submitted to the analytical laboratory "blind" (labeled using a pseudonym site name). Below are three examples of composite sample splitting procedures:

<u>Sample Splitting Example #1</u>

1. Sample storage bottles are labeled for specific analyses.
2. Clean powder-free nitrile gloves are worn for handling of bottles and lids.
3. Any item that will contact the sample is cleaned using protocols presented in ***Appendix E*** in Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a).
4. Clean, specially blown borosilicate glass vessels are used to composite and mix samples (vessels have glass spigots with Teflon stopcocks).
5. Clean, Teflon coated magnetic mixing bars are used to stir the sample continuously before and during sample pour-off into individual sample containers (check with the toxicity laboratory for recommended sample volumes for toxicity tests).

<u>Sample Splitting Example #2</u>

1. Sample storage bottles are labeled for specific analyses.
2. Clean powder-free nitrile gloves are worn for handling of bottles and lids.
3. Any item that will contact the sample is cleaned using protocols presented in ***Appendix E*** in Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a).
4. During continuous manual composite sample agitation, sample is drawn from the bottle into individual sample containers using a portable peristaltic pump and clean tubing (check with the toxicity laboratory for recommended sample volumes for individual toxicity tests).

Sample Splitting Example #3 (USGS method)

1. Sample storage bottles are labeled for specific analyses.
2. Clean powder-free nitrile gloves are worn for handling of bottles and lids.
3. The composite sample is mixed thoroughly by carefully shaking composite bottle, with lid in place, until the sample is well mixed.
4. Immediately after mixing, the composite sample is poured into a clean Teflon funnel/splitter with clean tubes leading to individual sample containers (check with the toxicity laboratory for recommended sample volumes for toxicity tests).

Sample Splitting Example #4

1. Sample storage bottles are labeled for specific analyses.
2. Clean powder-free nitrile gloves are worn for handling of bottles and lids.
3. The composite sample is mixed thoroughly by carefully shaking composite bottle, with lid in place, until the sample is well mixed. For large composite bottles, the use of a swiveling mechanical bottle holding/mixing/pouring device is recommended.
4. Immediately after mixing, the composite sample is poured off into individual sample storage bottles and the bottles are capped (check with the toxicity laboratory for recommended sample volumes for toxicity tests). Step 3 is repeated immediately prior to filling each sample storage bottle.

SAMPLE PRESERVATION AND HOLDING TIME

Preservation

To minimize loss of toxicity due to volatilization of toxic constituents, all containers must be completely filled, leaving no head space between the contents and the lid. All samples are kept on ice or refrigerated to 4° Celsius from the time of sample collection until delivery to the analytical laboratory. Refrigerated automatic samplers are ideal for keeping composite samples cool during sample collection. Where refrigerated automatic samplers are not used, composite samples are kept on ice from the time sampling is initiated. Ice is checked regularly to insure that the sample is kept cool. Grab samples are placed in an ice chest with ice immediately following collection.

In addition to keeping stormwater samples cool it is also important to minimize the exposure of the samples to direct sunlight, as sunlight may cause chemical and or biological alteration of the sample, resulting in unreliable results. Use of opaque plastic cubitainers or amber glass bottles should be used to reduce light exposure and all samples should be covered or placed in an ice chest with a closed lid immediately following collection or removal from the automatic sampler enclosure.

Holding Time

It is imperative that all samples be delivered to the toxicity testing laboratory within 24 hours, and toxicity tests initiated within 36 hours. This is the acceptable holding time for freshwater acute and chronic toxicity tests. When more than one grab sample is taken or a composite sample is collected, sample holding time begins when the last grab sample in a series is taken, or when a 24-hr composite sampling period is completed. The Chain-of-custody (COC) form should clearly indicate the time of sample collection.

SAMPLE DELIVERY/CHAIN OF CUSTODY

All samples must be kept on ice, or refrigerated, from the time of onset of sample collection to the time of receipt by laboratory personnel. Composite samples should be kept on ice or refrigerated from the onset. If samples are being shipped to the laboratory, place sample bottles inside coolers with ice (wet ice is preferable to gel ice), ensure that the sample bottles are well packaged (i.e. with bubble wrap, foam, etc.), and secure cooler lids with packaging tape.

To minimize the risk of exceeding the 36 hour holding time, samples must be transferred to the toxicity laboratory as soon as possible after sampling, but must arrive at the toxicity laboratory no more than 24 hours after sample collection. The field crew must coordinate activities with the toxicity laboratory to ensure that the holding time can be met, especially for samples collected at night or on weekends. The sampling crew must contact the laboratory prior to sample collection to provide some indication as to when the laboratory should expect to receive the samples. This notice should be provided as soon as possible (i.e. during the pre-alert stage when a target storm is expected within the next 72 hours), and should be followed by notice to the laboratory once sample collection has commenced. This should allow the laboratory sufficient time to prepare for testing (e.g. obtain organisms, arrange for staff, etc.). For Caltrans toxicity studies, laboratories should preorder any required organisms in anticipation of stormwater samples and make arrangements to have staff available. Additionally, to limit the logistical issues (and associated costs), whenever possible, toxicity testing should be requested for samples anticipated from storms targeted between Monday through Friday. This will allow labs to commence testing during weekday hours.

COC forms must be filled out by the sampling team for all samples submitted to the toxicity laboratory. The purpose of COC forms is to keep a record of the transfer of sample custody, and requested analyses. Sample date, sample location, and analysis requested are noted on each COC, including specification of lab quality control requirements (e.g., laboratory duplicate samples; see ***Section 8***). Any special instructions for the laboratory should also be noted (e.g., request for follow-up TIEs). Customized project specific COCs, that include standard information (e.g., contact information, constituents and methods, and special notes) are recommended. Copies of COC forms are kept with field notes in a field log book. COC forms should be checked to be sure all analyses specified by the sampling plan are included. Review of the COC forms

immediately following a storm event gives the data reviewer a chance to review the field crews' requests and then to notify the laboratory of additional analyses or necessary clarification. An example of a customized COC form is presented as Figure 7-1.

Laboratory Name Laboratory Address

CHAIN-OF-CUSTODY RECORD **DATE:** **Lab ID:**

Client:	
Address:	
Sampled By:	
Phone:	
FAX:	
Project Manager:	
Project Number:	

Client Sample ID	**Sample Date**	**Sample Time**	**Sample Matrix**	**Container #**	**Container Type**	**REQUESTED ANALYSIS** Acute toxitiy *C. dubia*	Acute toxicity *P. promelas*										**Special Instructions/ Comments**
7-125			SW	1	1L glass	X											screening
10-128			SW	2	1L glass		X										dilution series

Correct Containers:	Yes	No		
Sample Temperature:	Ambient	Cold	Warm	
Sample Preservative:	Yes	No		
Turnaround Time:	Normal	Specify:	10/30 days	fax/final

Comments:

RELIQUINSHED BY		**RECEIVED BY**	
Signature:		Signature:	
Print:		Print:	
Company:		Company:	
Date:	Time:	Date:	Time:
Signature:		Signature:	
Print:		Print:	
Company:		Company:	
Date:	Time:	Date:	Time:
Signature:		Signature:	
Print:		Print:	
Company:		Company:	
Date:	Time:	Date:	Time:

Figure 7-1. Example Chain-of-Custody Form

SECTION 8
QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

The quality of toxicity data is dependent on the manner in which samples are collected, handled and analyzed. To ensure that data meet project data quality acceptability limits or objectives (DQOs,) a Data Quality Evaluation Plan (DQEP) should be included in the sampling and analysis plan (SAP) prior to implementing the toxicity study. The DQEP should include QA/QC review procedures for both field and laboratory measures (see ***Section 6*** and the QA/QC data evaluation discussion below).

This section covers the following topics:

- **Blank Samples**
- **Duplicate Samples**
- **QC Sample Schedule**
- **Lab-Initiated QA/QC**
- **QA/QC Data Evaluation**

For aquatic toxicity tests, the acceptability of test results is determined primarily by performance-based criteria for test organisms, culture and test conditions, and the results of control bioassays. Control bioassays include testing with reference toxicants and negative controls (dilution water). Test acceptability requirements are documented in the method documents for each bioassay method.

QA practices for toxicity testing methods must address all factors that affect the quality of the final toxicity test data, such as:

- Sample collection and handling
- The source and condition of the test organisms
- Condition of equipment
- Test conditions
- Instrument calibration
- Replication
- Use of reference toxicants

In addition to the QA requirements for toxicity testing methods, a designated percentage of samples collected for toxicity studies should be reserved for QC analyses. These analyses should consist of laboratory duplicates and field blanks. This section discusses the QA/QC samples, as listed below, that should be included in toxicity studies. Additionally, a QC schedule should be developed to outline the types and frequency of QC samples to be conducted during a given toxicity study. Finally, data should be

evaluated to determine whether the project's data quality acceptability limits or objectives (DQOs) have been met.

BLANK SAMPLES

Blanks are prepared to identify potential sample contamination occurring during field collection, handling, shipment, storage, and laboratory handling and analysis. Blanks are prepared during various stages of the sampling and analytical process to determine the level of contamination, if any, introduced at each step. The collection and uses of the types of blank samples associated with typical stormwater monitoring field procedures and toxicity test methods are described below. "Blank water" for toxicity studies refers to the standard dilution water[1] that is prepared and utilized by the toxicity laboratory performing the environmental and blank analyses. Laboratory dilution water is also used for test controls.

Equipment Blanks

Before using sampling equipment for environmental sample collection, blanks should be collected to verify that the equipment is not a source of sample contamination. Stormwater monitoring programs normally include equipment blanks to check sample tubing and strainers, and sample bottles. Equipment blanks are usually prepared at the beginning of the monitoring season, and are collected by passing blank water through clean equipment. Equipment blank samples are collected using clean techniques, prior to on-site sample collection (before the equipment has been contaminated by environmental sample water or other sources). Equipment blank collection normally requires a two-person field crew. After collection, equipment blanks are capped, placed in an ice chest with ice and delivered to the analytical laboratory in the same manner as environmental samples.

If using manual collection methods (i.e. bailers), fill the bailer or other collection device with blank water in the field and pour the water into clean sample bottle(s). If an automatic sampler is being used, place the cleaned strainer on the end of the clean tubing, and install the tubing through the sampler. Do not install the tubing and strainer into the pipe or channel, but leave the tubing coiled up beside the sampler. Prevent the strainer or exposed tubing end from contacting anything other than the inside of a new plastic bag during this process. Then insert the strainer into the bottle containing the blank water and pump the sample through the clean suction tubing, into clean composite bottle(s) and/or grab sample containers.

---

[1] A synthetic (standard) dilution water (moderately hard water) is normally used for the types of tests outlined in this guidance document. References to blank water in this section refers to toxicity laboratory dilution water.

Equipment blanks are analyzed using the same methods as those used for normal sample analysis and submitted to the toxicity laboratory "blind" (disguised as a regular environmental sample by labeling with a pseudonym).

Field Blanks

Field blanks are necessary to evaluate whether contamination is introduced during field sampling activities. Field blanks are prepared by the field crew, under normal sample collection conditions, at some time during the collection of normal stormwater samples. Field blanks are prepared by filling a large carboy or other appropriate container with blank water, transporting the container to the field and processing the water through the same sampling procedures to be used for sample collection. If grab sample collection is conducted, grab sample field blanks should be prepared by pouring a sample directly from the bottle of blank water, into the grab sample containers. Grab sample blanks should imitate environmental sampling as closely as possible by using grab poles, clean intermediate containers, and other clean equipment in the same manner. For composite field blanks, pour the blank water directly into clean composite bottles at the sampling site, label as an environmental sample, and submit “blind” to the laboratory. The filled blank sample bottles should be sealed and sent to the laboratory to be analyzed for the required constituents.

In addition to the minimum field blank collection requirements indicated in Table 8-1, it is important that field blanks are collected at a frequency no less than once per field sampling team per sampling season. Additional blanks should be collected when there is a change in sampling personnel, equipment, or procedures. It may also be desirable to prepare field blanks prior to any actual sampling events as an advance check of the overall sampling procedures.

DUPLICATE SAMPLES

Laboratory duplicates are used to assess the precision of the toxicity testing method and laboratory handling (intra-laboratory variability). For laboratory duplicate samples, one sample will be split by the toxicity laboratory into two portions and each tested. When collecting samples to be analyzed for laboratory duplicates, the normal sample volume required should typically be doubled. This requires filling a larger size sample bottle (preferred), or filling two normal size sample bottles.

QC SAMPLE SCHEDULE

Table 8-1 summarizes the recommended frequencies of QC sample collection/ preparation for Caltrans toxicity studies. These frequencies are minimum and may be increased depending on the nature and objectives of the study being undertaken or if QA/QC problems (e.g. contamination) are discovered. An adequate QC sample schedule should be included in the analytical budget for the toxicity study.

A QC sample schedule should be developed, included in the SAP, and followed closely by field personnel. The project QC sample schedule should meet the minimum QC sample frequency criteria over the term of the project. In some cases, QC samples at one site may be applied to an analogous situation at another site. For example, if the same equipment and protocols are used at Site A and Site B, equipment blank checks at one site can be applied at both sites. The minimum frequency criteria must still be met; however, the QC sample schedule should consider the location of each QC sample to maximize coverage at all project sites. A QC sample schedule should, at a minimum, indicate the types and frequency of QC sample collection, site of QC sample collection, and QC sample pseudonyms for samples that will be submitted "blind" to the laboratory.

Table 8-1. Recommended QC Sample Frequency

QA/QC Sample Type	***Minimum Sampling Frequency***
Equipment Blank	Equipment blanks should be collected prior to each sampling season for each sampling method to be utilized (e.g. automated, manual).
Field Blank	One field blank should be collected per storm event/batch of samples. The site at which the field blank is collected should be rotated throughout the course of the study.
Laboratory Duplicate	Ten percent of the samples collected for aquatic toxicity testing should be split and tested in duplicate by the toxicity laboratory.
Reference Toxicants (see following section)	Toxicity laboratories must run a reference toxicant test monthly.

1 A batch is defined as the group of bottles that have been cleaned at the same time, in the same manner; or, if certified bottles are sent directly from the manufacturer, the batch would be the lot designated by the manufacturer in their testing of the bottles.

LAB-INITIATED QA/QC

QA/QC measures initiated by the toxicity laboratory include toxicity controls and reference toxicants.

Toxicity Controls

For aquatic toxicity testing, a control consisting of dilution water is run with every test. These toxicity controls are run side by side with environmental samples tested during each toxicity test conducted by the laboratory. Control treatments (organisms in unaltered dilution water) provide an important reference for dilution water and organism acceptability. Results of toxicity controls are used to determine the acceptability and significance of toxicity test results (see test acceptability criteria discussion in this section).

Reference Toxicants

Toxicity laboratories must conduct reference toxicant tests for each type of test to be used in the laboratory. For a given test method, successive tests must be performed with the same reference toxicant, at the same concentrations, in the same dilution water, using the same data analysis methods. According to U.S. EPA guidance (U.S. EPA, 1993a, 1994), the laboratory must conduct reference toxicant tests at a frequency no less than once per month. ***However, when possible, reference toxicant tests should be conducted when Caltrans samples are being tested in-house***.

QA/QC DATA EVALUATION

All data reported by the analytical laboratory must be carefully reviewed to determine whether the project's data quality acceptability limits or objectives (DQOs) have been met. The data review methods should be outlined in a DQEP developed for the project. A detailed discussion of the QA/QC data evaluation process for Caltrans stormwater monitoring programs is presented in Part II, Caltrans Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a). This process includes two steps; initial data quality screening and data quality evaluation.

Data quality screening includes the following:

1. Verification check between sampling and analysis plan (SAP), chain of custody forms, and laboratory data reports;
2. Check of laboratory data report completeness; and
3. Check for typographical errors and apparent incongruities.

See the Caltrans Monitoring Protocol Guidance Manual: Water Quality (Caltrans, 2000a) for details concerning the above.

The data quality evaluation process for toxicity data is significantly different from the process developed for water chemistry. Data evaluation as it relates to toxicity testing includes review of the following QA/QC parameters:

- Holding times
- Test acceptability criteria
- Contamination check results (field, bottle, and equipment blanks)
- Precision and accuracy analysis (laboratory duplicates, reference toxicants)

Evaluation of each of these components is discussed below. Guidelines for evaluating these QA/QC elements are presented in Figure 8-1.

Holding Times

> ***Holding Times***
>
> Delivery to lab = within 24 hours
>
> Test initiation = within 36 hours

Holding time represents the period of time between sample collection and initiation of the toxicity test(s). Calculate the time elapsed between sampling and start of toxicity test initiation, and compare this to the required holding time. For composite samples that are collected within 24-hours or less, the time of the final sample aliquot is considered the "sample collection time" for determining sample holding time. Because toxicity test methods have a critical holding time (≤36 hours), sampling crews must take into account the time required to transport the sample to the laboratory. Sampling crews must notify the toxicity laboratory prior to and upon commencment of sample collection; and samples must arrive at the toxicity laboratory no later than 24 hours after collection. The COC form should clearly indicate the time of sample collection. If sampling crews fail to contact the laboratory prior to sample collection and/or samples older than 24 hours are received by the laboratory, the laboratory will not be held accountable for missed holding times. If the 36 hour holding time is exceeded, the laboratory should discard the samples.

Test Acceptability Criteria

Test acceptability criteria are used to demonstrate the sensitivity of the test organisms and the laboratory performance with a routine reference toxicant. Data acceptability criteria for each acute and chronic toxicity method (as outlined in ***Section 4***) are presented in Table 8-2 . If the test acceptability criteria are not met, the acceptability of the test will depend on the best professional judgment of the laboratory investigator. Any failure to meet the criteria must be noted when reporting data from a test. Efforts should be taken by the laboratory to resolve potential problems made evident by the test results.

In addition to acceptable criteria for control organisms, U.S. EPA toxicity test methods outline acceptable ranges for test conditions such as DO, pH, and temperature. An individual test may be conditionally acceptable if these specified conditions fall outside specifications, depending on the degree of the departure and the objectives of the tests. The acceptability of the test will depend on the experience and professional judgement of the laboratory analyst and/or the reviewing staff of the regulatory authority. Any deviation from test specifications must be noted by the laboratory when test data are reported (U.S. EPA, 1993a, 1994).

Table 8-2. Aquatic Toxicity Test Acceptability Criteria

Test Method	Acceptability Criteria
Acute	
Ceriodaphnia dubia	90% or greater survival in controls
Pimephales promelas	90% or greater survival in controls
Oncorynchus mykiss	90% or greater survival in controls
Chronic	
Ceriodaphnia dubia	80% or greater survival and an average of 15 or more young per surviving female in the control solutions. 60% of surviving control organisms must produce three broods.
Pimephales promelas	80% survival in the controls, average dry weight per surviving organism in control chambers equals or exceeds 0.25 mg.
Selenastrum capricornutum	1 x 10^6 cells/mL with EDTA or 2 x 10^5 cells/mL without EDTA in the controls, variability of controls should not exceed 20%.

Contamination

Blank samples are used to identify the presence and potential source of sample contamination and as mentioned above typically include field blanks, bottle blanks, and equipment blanks. If toxicity is observed in blanks a complete review of field procedures and sample handling should be conducted as well as a detailed review of raw laboratory data and procedures. Often times it is necessary to refer to historical equipment blank results, if available, corresponding data (e.g. controls, reference toxicant tests), and field notes to identify contamination sources. This is a corrective and documentative step in the QA/QC process that should be conducted as soon as toxicity is reported for any blanks.

Precision and Accuracy

Reference Toxicant Tests

It is a laboratory's responsibility to demonstrate its ability to obtain consistent and accurate results with appropriate reference toxicants before it performs toxicity tests with environmental samples. To meet this requirement, the intralaboratory precision, expressed as percent coefficient of variation (CV%), of each type of test to be used in the laboratory, should be determined by performing five or more tests with different batches of test organisms, using the same reference toxicant, at the same concentrations, with the same test conditions (i.e. duration, type of dilution water, age of test organisms, feeding, etc.), and same data analysis methods. These reference toxicant tests assess the accuracy and precision in the same way that repeated analysis of standard reference materials (SRM) provides both accuracy and precision for chemical analyses. A reference toxicant concentration series (0.5 or higher) should be selected that will consistently provide partial mortalities at two or more concentrations.

Toxicity endpoints from the most recent 25 reference toxicant tests should be used to construct control limits. The control limits consist of two standard deviations above and below the concentration representing the central tendency. An example control chart is illustrated in Figure 8-2. Outliers, which fall outside of the upper and lower limits, and trends of increasing or decreasing sensitivity, are readily indentified using this method. Control limits of $\pm$ 2 standard deviations will be exceeded 5% of the time by chance alone, regardless of how well a laboratory performs (U.S. EPA, 1993, 1994). Additionally, highly proficient laboratories which develop very narrow control limits may be unfairly penalized if a test result which falls just outside the control limits is rejected *de facto*. For this reason, the width of the control limits should be considered when determining whether the outliers should be rejected (U.S. EPA, 1995). Laboratories should consult U.S. EPA (2000) additional information on method variability in toxicity applications.

If the toxicity value from a given test with a reference toxicant falls well outside the expected range for the other test organisms when using the standard dilution water and test conditions, the sensitivity of the organisms and the overall credibility of the test should be considered as provisional and subject to careful review. In this case, the test procedure should be examined for defects and efforts should be made to resolve the problem.

Laboratory Duplicates

Laboratory duplicates are used to assess the precision of the toxicity method and laboratory handling. Duplicates should not be significantly different at the 5% level of significance, acceptability of the test will be depend on the best professional judgment of the laboratory investigator through careful review of results.

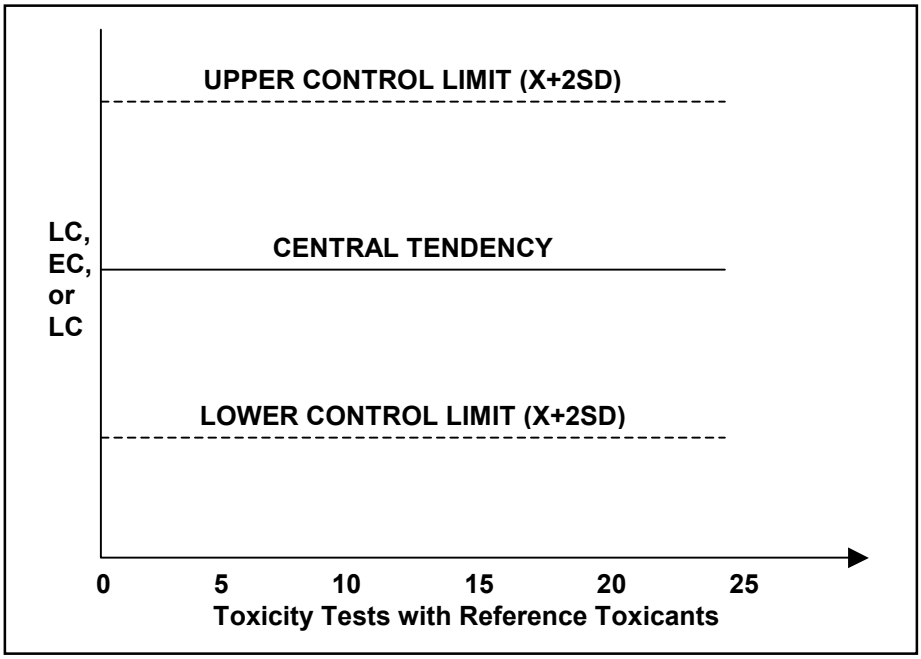

Figure 8-2. Example Reference Toxicant Control Chart

SECTION 9
LABORATORY CONTRACTING AND PROCEDURES

This section describes considerations involved in selecting and contracting with toxicity laboratories, the steps to be taken by toxicity laboratories to prepare for monitoring events, and the procedures laboratories will use for toxicity testing of stormwater samples. The following topics are discussed:

- **Laboratory Selection and Contracting**
- **Pre-Sampling Preparations**
- **Sample Storage and Handling Prior to Analysis**
- **Toxicity Test Methods**
- **Laboratory Data Package Deliverables**

LABORATORY SELECTION AND CONTRACTING

Important considerations in selecting a toxicity laboratory include performance, ability to meet test acceptability criteria, and experience with the types of toxicity testing included in the study. The laboratory should have a proven record of performance with the sample matrices involved in the study and the particular types of toxicity tests to be conducted for the project. Additionally, Department of Health Services (DHS) certification is required for Caltrans analytical and toxicity testing work.

It is important to ensure that the selected toxicity laboratory has proven satisfactory performance. The ability of the laboratory to obtain consistent, precise results must be demonstrated with reference toxicants. Reference toxicant data should be checked for values outside of the upper and lower control limits (see ***Section 8***). Data from laboratory controls should also be checked to ensure that the laboratory can consistently meet the test acceptability criteria established for controls.

Finally, it is necessary that laboratories be made contractually accountable to meet all Caltrans' data quality acceptability limits or objectives (DQOs) and project specifications. This is discussed in more detail later in this section.

PRE-SAMPLING PREPARATIONS

The laboratory will be involved in a number of activities prior to the actual testing of stormwater samples, including:

- Determination of key laboratory performance requirements (e.g., turnaround times, report formats) for toxicity testing services contract.

- Review and comment on the SAP and the data quality evaluation plan (DQEP), QC sample schedule, and QC sample volumes. This overall package is sometimes referred to as the QA/QC plan.
- Approach for conducting TIEs, if included in the study.
- Providing sampling team with clean sample containers and blank water.
- Coordination with sampling team prior to each anticipated storm sampling event.

These items are further discussed below.

Determination of Laboratory Performance Criteria

The toxicity laboratory must test the stormwater samples using methods that will achieve Caltrans' DQOs for the project (see ***Section 2***). The contract for toxicity testing services should specify laboratory performance criteria designed to ensure that the project DQOs will be met. The contract should specify the following:

- Test acceptability criteria
- Holding times
- Types and frequency of QA/QC analyses to be performed
- Quality control performance guidelines
- Sample turnaround times
- Electronic and hard copy report formats
- Corrective action procedures

In addition, the contract with the laboratory should specify that at least 90% of the sample results must meet the QA/QC criteria and be deemed usable for the project.

Laboratory Input to Project QA/QC Plan

The contract laboratory should review and provide input on the SAP and the QA/QC plan for each Caltrans toxicity study. This input will help ensure that the correct sample containers, sample volumes, holding times, and testing methods are specified, as well as the correct points of contact for communications between field and laboratory personnel. In addition, the laboratory should be involved early in the process so they can provide feedback on methods and performance standards during the planning phase.

Sample Containers, Blank Water

As discussed in ***Section 7***, sampling personnel will need to request the appropriate containers from the laboratory prior to each sampling event. The containers needed for a given project will vary depending on the toxicity test methods (i.e. if TIEs are planned) sample collection procedure, and the DQOs. For example, stormwater monitoring programs often include composite samples, wherein subsamples collected during a storm

event may be combined in one or more large containers. After the composite sample has been delivered to the laboratory, water is transferred from the composite sample containers into the appropriate containers. U.S. EPA methods for acute and chronic toxicity testing (U.S. EPA 1993, 1994) recommend the use of 4-liter (1 gallon) cubitainers for sample containment. However, U.S. EPA TIE methods (U.S. EPA, 1991) state that glass containers are preferable to plastic when TIE issues are of concern (see bottle selection discussion in ***Section 7***). As noted above, the toxicity laboratory should review the QA/QC plan for each Caltrans toxicity study to ensure that the plan specifies the appropriate sample containers and volumes.

If a given project calls for collection of composite samples, the field personnel must obtain the appropriate composite sample containers from the laboratory; however, the field personnel do not need the individual containers required for toxicity sample containment if the lab will be doing the composite sample breakdown. The composite sample bottle container must be large enough to provide sufficient volume of sample for all of the planned tests. Bottle contamination issues should always be assessed with blank samples, regardless of the bottle material (see ***Section 8***).

For toxicity studies that specify collection of grab samples, field personnel must obtain the appropriate pre-cleaned bottles from the laboratory prior to the sampling event. Bottles should be rinsed prior to sample collection according to the instructions presented in ***Section 7***.

Recommended sample volumes for acute and chronic toxicity tests are presented in Table 9-1. However, sample volumes should be confirmed with the laboratory prior to sample collection, including sufficient sample volumes for TIE follow-up testing (if this is planned) and required laboratory QA/QC analysis. As discussed in ***Section 8***, laboratory QC samples that make use of sample water provided by the field crew include laboratory duplicates. Duplicates typically require double the normal sample volume required.

If field blanks are to be collected, the laboratory also will need to provide sufficient quantities of blank water and appropriate containers (see ***Section 8***). The blank water supplied by the laboratory should be the same as the water used for dilution and toxicity controls.

Laboratory Coordination Prior to a Sampling Event

It is important for the sampling task manager to notify the laboratory of an anticipated storm sampling event so that the laboratory can prepare for possible off-hour sample delivery, and to make preparations to meet the 36 hour holding time for toxicity test initiation. The laboratory contact should be notified regarding the number of samples anticipated, approximate date and time of sampling (if known), and when sample containers, blank water or ice chests will be required.

In addition, the laboratory should be made aware of specific project requirements such as required laboratory performance objectives, required QC samples, and reporting requirements.

Table 9-1. Toxicity Method and Sample Specifications

Test Species	U.S. EPA Method Reference	Test Duration	Container Type [1]	Sample Volume Required [2]	Holding Time	Storage
Acute						
Ceriodaphnia dubia	EPA/600/ 4-90/027	24, 48, or 96 hrs	PE or glass	1 L	36 hrs	4° C
Pimephales promelas	EPA/600/ 4-90/027	24, 48, or 96 hrs	PE or glass	2 L	36 hrs	4° C
Oncorhynchus mykiss	EPA/600/ 4-90/027	24, 48, or 96 hrs	PE or glass	20 L	36 hrs	4° C
Chronic						
Ceriodaphnia dubia	EPA/600/4-91/002 (method 1002.0)	Max. 8 days [3]	PE or glass	7 L (1.0 L/day)	36 hrs	4° C
Pimephales promelas	EPA/600/4-91/002 (method 1000.0)	7 days	PE or glass	17.5 L (2.5 L/day)	36 hrs	4° C
Selenastrum capricornutum [5]	EPA/600/4-91/002 (method 1003.0)	96 hrs	PE or glass	1 or 2 L [4]	36 hrs	4° C

[1] If TIE follow-up tests are planned, samples should be collected in glass containers.
[2] Volume requirements are minima additional volume is needed if TIE follow-up is planned.
[3] Test is conducted until 60% of surviving control organisms have three broods.
[4] Is dependant upon test solution volume selected. This should be verified with the toxicity laboratory prior to sample collection.
[5] Species name has been changed to *Raphidocelis subcapitata.*

SAMPLE STORAGE AND HANDLING PRIOR TO ANALYSIS

To minimize the chance of sample contamination and unreliable results, special measures must be taken during the storage and handling of samples prior to analysis. For example, toxicity samples must be collected and stored in the appropriate containers at 4°C. If composite samples are collected, sample splitting must be conducted to properly store the samples. In addition, some toxicity test methods require filtration of the sample prior to test initiation. Finally, samples must be analyzed within established holding times to ensure reliability of the results. Each of these measures is discussed in more detail below and summarized in Table 9-1 for specific toxicity test methods.

Composite Splitting

If composite sampling procedures are used, the composite samples may need to be split prior to toxicity test initiation. It is recommended that composite sample splitting be conducted by the laboratory or in another similarly controlled environment to minimize the chance of contamination. Clean techniques should be used when handling and splitting the composite sample. Sample splitting procedures are explained in detail in ***Section 7***.

Sample Filtration

For toxicity tests utilizing *Ceriodaphnia dubia* or *Pimephales promelas* (fathead minnows), samples must be filtered through a 60 micrometer (μm) plankton net to remove indigenous organisms that may attack or be confused with the test organisms. Samples should be filtered in the laboratory as required for specific toxicity tests.

Sample Handling and Preservation

To minimize the loss of toxicity due to volatilization, all sample containers should be completely filled, leaving no air space between the contents and the lid. Samples should be chilled and maintained at $4^{o}C$ until used for toxicity testing to inhibit microbial degradation, chemical transformations, and loss of highly volatile toxic substances.

Holding Times

Every effort must be made to initiate toxicity tests with a stormwater sample on the day of arrival in the laboratory, and the sample holding time should not exceed 36 hours (see ***Section 8***).

TOXICITY TEST METHODS

Test methods should be selected that are sufficient to meet the DQOs for each project (***Section 2*** describes how project DQOs are developed). As discussed in ***Section 4***, toxicity test methods are selected based on regulatory and legal requirements, historical data, BMP goals, and other considerations.

In selecting the toxicity test method(s) to be used, the following questions should be addressed:

- Does the method conform to any legal or regulatory requirements for the monitoring program?
- Is the method appropriate for stormwater samples (has the laboratory successfully performed the method using stormwater samples)?
- Will the data provided by the method be comparable to historical data collected at the station?

- Is the method recognized as "standard" so that the data collected at a station can be compared to other stations?
- Is the laboratory proficient with the method? Do they have historical data to show proficiency?

As indicated in ***Section 4***, the toxicity test types recommend for use in Caltrans toxicity studies include freshwater acute testing using *Ceriodaphnia dubia*, *Pimephales promelas*, and *Oncorhynchus mykiss*; and chronic testing using *Ceriodaphnia dubia, Pimephales promelas,* and *Selenastrum capricornutum*. Summaries of the testing protocols for each of these tests are presented in Tables 9-2 through 9-7.

LABORATORY DATA PACKAGE DELIVERABLES

As a part of the laboratory contract, the data package that will be delivered to Caltrans and the timing of its delivery (turn around time) should be defined. The data package should include a narrative that outlines any problems, corrections, anomalies, and conclusions, as well as completed chain of custody documentation. A list of the minimum reporting parameters that should be included in the toxicity laboratory's report for each toxicity test is presented in Figure 9-1. The laboratory should include specifics concerning QA/QC results including the following:

- Adherence to holding times
- Any violations of test acceptability criteria
- Interpretation of field, bottle, and equipment blanks results
- Interpretation of laboratory duplicates, reference toxicants

Common turn around times for laboratory data packages three weeks to thirty days for the hard copy. The hard copy data package and any electronically supplied data should undergo data review as described in ***Section 8***.

Table 9-2. Summary of Test Conditions for *Ceriodaphnia dubia* Acute Toxicity Tests

Test type:	Static non-renewal or static renewal
Test duration:	24, 48, or 96 h
Temperature:	20 ± 1^0 C; or 25 ± 1^0 C
Light quality:	Ambient laboratory illumination
Light intensity:	10-20 $\mu E/m^2/s$ (50-100 ft-c) (ambient laboratory levels)
Photoperiod:	16 h light, 8 h darkness
Test chamber size:	30 mL (minimum)
Test solution volume:	15 mL (minimum)
Renewal of test solutions:	Minimum, after 48 h
Age of test organisms:	Less than 24-h old
No. organisms per test chamber:	Minimum, 5
No. replicate chambers per concentration:	Minimum, 4
No. organisms per concentration:	Minimum, 20
Feeding regime:	Feed YCT[1] and *Selenastrum* while holding prior to test; newly-released young should have food available a minimum of 2 h prior to use in a test; add 0.1 mL each of YCT and Selenastrum 2 h prior to test solution renewal at 48 h
Test chamber cleaning:	Not required
Dilution water:	Moderately hard synthetic water
Test concentrations:	Screening level tests – 100% and control Dilution series – to be determined depending on the objectives of the study
Endpoint:	Mortality (see ***Section 10*** for more information)
Sampling and sample holding requirements:	Grab or composite samples are used within 36 h of completion of the sampling period (see ***Section 8***)
Test acceptability criterion:	90% or greater survival in controls

1 YCT = a mixture of yeast, digested trout chow, and cereal leaves (dried and powdered).

Table 9-3. Summary of Test Conditions for Fathead minnow, *Pimephales promelas* Acute Toxicity Tests

Test type:	Static non-renewal or static renewal
Test duration:	24, 48, or 96 h
Temperature:	20 ± 1^0 C; or 25 ± 1^0 C
Light quality:	Ambient laboratory illumination
Light intensity:	10-20 $\mu E/m^2/s$ (50-100 ft-c) (ambient laboratory levels)
Photoperiod:	16 h light, 8 h darkness
Test chamber size:	250 mL (minimum)
Test solution volume:	200 mL (minimum)
Renewal of test solutions:	Minimum, after 48 h
Age of test organisms:	1-14 days; 24-h range in age
No. organisms per test chamber:	Minimum, 10
No. replicate chambers per concentration:	Minimum, 2
No. organisms per concentration:	Minimum, 20
Feeding regime:	*Artemia* nauplii are made available while holding prior to the test; add 0.2 mL *Artemia* nauplii concentrate 2 h prior to test solution renewal at 48 h
Test chamber cleaning:	Not required
Test solution aeration:	None, unless DO concentration falls below 4.0 mg/L; rate should not exceed 100 bubbles/min
Dilution water:	Moderately hard synthetic water
Test concentrations:	Screening level tests – 100% and control Dilution series – to be determined depending on the objectives of the study
Endpoint:	Mortality (see ***Section 10*** for more information)
Sampling and sample holding requirements:	Grab or composite samples are used within 36 h of completion of the sampling period (see ***Section 8***)
Test acceptability criterion:	90% or greater survival in controls

Table 9-4. Summary of Test Conditions for Rainbow Trout, *Oncorhynchus mykiss* Acute Toxicity Tests

Test type:	Static non-renewal or static renewal
Test duration:	24, 48, or 96 h
Temperature:	12 ± 1^0 C
Light quality:	Ambient laboratory illumination
Light intensity:	10-20 $\mu E/m^2/s$ (50-100 ft-c) (ambient laboratory levels)
Photoperiod:	16 h light, 8 h darkness. Light intensity should be raised gradually over a 15 minute period at the beginning of the photoperiod, and lowered gradually at the end of the photoperiod, using a dimmer switch or other suitable device.
Test chamber size:	5 L (minimum)
Test solution volume:	4 L (minimum)
Renewal of test solutions:	Minimum, after 48 h
Age of test organisms:	15-30 days (after yolk sac absorption to 30 days)
No. organisms per test chamber:	Minimum, 10
No. replicate chambers per concentration:	Minimum, 2
No. organisms per concentration:	Minimum, 20
Feeding regime:	Feeding not required
Test chamber cleaning:	Cleaning not required
Test solution aeration:	None, unless DO concentration falls below 6.0 mg/L; rate should not exceed 100 bubbles/min
Dilution water:	Moderately hard synthetic water
Test concentrations:	Screening level tests – 100% and control Dilution series – to be determined depending on the objectives of the study
Endpoint:	Mortality (see ***Section 10*** for more information)
Sampling and sample holding requirements:	Grab or composite samples are used within 36 h of completion of the sampling period (see ***Section 8***)
Test acceptability criterion:	90% or greater survival in controls

Table 9-5. Summary of Test Conditions for *Ceriodaphnia dubia* Chronic Toxicity Tests

Test type:	Static renewal
Temperature:	25 ± 1^0 C
Test duration:	Until 60% of surviving control organisms have three broods (maximum test duration 8 days)
Light quality:	Ambient laboratory illumination
Light intensity:	10-20 $\mu E/m^2/s$ (50-100 ft-c) (ambient laboratory levels)
Photoperiod:	16 h light, 8 h darkness
Test chamber size:	30 mL (minimum)
Test solution volume:	15 mL (minimum)
Renewal of test solutions:	Daily
Age of test organisms:	Less than 24-h old; all released within a 8-h period
No. neonates per test chamber:	1
No. replicate chambers per concentration:	10
No. neonates per concentration:	10
Feeding regime:	Feed 0.1 mL each of YCT[1] and algal suspension per test chamber daily
Cleaning:	Use freshly cleaned glass beakers or new plastic cups daily
Aeration:	None
Dilution water:	Moderately hard synthetic water
Test concentrations:	Screening level tests – 100% and control Dilution series – to be determined depending on the objectives of the study
Endpoint:	Survival and reproduction (see ***Section 10*** for more information)
Sampling and sample holding requirements:	Grab or composite samples are used within 36 h of completion of the sampling period (see ***Section 8***)
Test acceptability criterion:	80% or greater survival and 15 or more young per surviving female in the control solutions. 60% of surviving control organisms must produce three broods.

1 YCT = a mixture of yeast, digested trout chow, and cereal leaves (dried and powdered).

Table 9-6. Summary of Test Conditions for Fathead minnow, *Pimephales promelas* Chronic Toxicity Tests

Test type:	Static renewal
Test duration:	7 days
Temperature:	25 ± 1^0 C
Light quality:	Ambient laboratory illumination
Light intensity:	10-20 $\mu E/m^2/s$ (50-100 ft-c) (ambient laboratory levels)
Photoperiod:	16 h light, 8 h darkness
Test chamber size:	500 mL (minimum)
Test solution volume:	250 mL (minimum)
Renewal of test solutions:	Daily
Age of test organisms:	Newly hatched larvae less than 24 h old. If shipped, not more than 48 h old, 24 h range in age
No. larvae per test chamber:	15 (minimum of 10)
No. replicate chambers per concentration:	4 (minimum 3)
No. larvae per concentration:	60 (minimum 30)
Source of food:	Newly hatched *Artemia* nauplii (less than 24-h old)
Feeding regime:	Feed 0.1 g newly hatched (less than 24-h old) brine shrimp nauplii three times daily at 4-h intervals or, as a minimum, 0.15 g twice daily, 6 h between feedings. Sufficient nauplii are added to provide an excess. Larvae fish are not fed during the final 12 h of the test.
Test chamber cleaning:	Siphon daily, immediately before test solution renewal
Test solution aeration:	None, unless DO concentration falls below 4.0 mg/L; rate should not exceed 100 bubbles/min
Dilution water:	Moderately hard synthetic water
Test concentrations:	Screening level tests – 100% and control Dilution series – to be determined depending on the objectives of the study
Endpoint:	Survival and growth (weight) (see ***Section 10*** for more information)
Sampling and sample holding requirements:	Grab or composite samples are used within 36 h of completion of the sampling period (see ***Section 8***)
Test acceptability criterion:	80% or greater survival in controls; average dry weight per surviving organism in control chambers equals or exceeds 0.25 mg

Table 9-7. Summary of Test Conditions for Alga, *Selenastrum capricornutum* Chronic Toxicity Tests

Test type:	Static non-renewal
Test duration:	96 h
Temperature:	25 ± 1^0 C
Light quality:	"Cool white" fluorescent lighting
Light intensity:	86 ± 8.6 µE/m^2/s (400 ± 40 ft-c or 4306 lux) (ambient laboratory levels)
Photoperiod:	Continuous illumination
Test chamber size:	125 mL or 250 mL[1]
Test solution volume:	50 mL or 100 mL[1]
Renewal of test solutions:	None
Age of test organisms:	4 to 7 days
Initial cell density in test chambers:	10,000 cells/mL
No. replicate chambers per concentration:	4 (minimum 3)
Shaking rate:	100 cpm continuous
Test solution aeration:	None
Dilution water:	Algal stock culture medium, enriched uncontaminated source of receiving water, synthetic water prepared using MILLIPORE MILLI-Q® or equivalent deionized water and reagent grade chemicals, or DMW (see U.S. EPA 1994)
Test concentrations:	Screening level tests – 100% and control Dilution series – to be determined depending on the objectives of the study
Endpoint:	Growth (cell counts, chlorophyll fluorescence, absorbance, biomass) (see ***Section 10*** for more information)
Sampling and sample holding requirements:	Grab or composite samples are used within 36 h of completion of the sampling period (see ***Section 8***)
Test acceptability criterion:	1×10^6 cells/mL with EDTA or 2×10^5 cells/mL without EDTA in the controls: Variability of controls should not exceed 20%

1 For tests not continuously shaken use 25 mL in 125 mL flasks and 50 mL in 250 mL flasks.

SAMPLE INFORMATION
1. Identify source water (field sample id, laboratory id) 2. Contract and task order numbers 3. Chain of custody
TEST METHODS
1. Toxicity test method used (title, number, source) 2. Endpoint(s) of test 3. Deviation(s) from reference method, if any, and the reason(s) 4. Date and time test started 5. Data and time test terminated 6. Type and volume of test chamber 7. Volume of solution used per chamber 8. Number of organisms per test chamber 9. Number of replicate test chambers per treatment 10. Acclimation of test organisms (temperature mean and range) 11. Test temperature (mean and range) 12. Specify if aeration was needed 13. Feeding frequency, and amount and type of food
TEST ORGANISMS
1. Scientific name and how determined 2. Age at test initiation 3. Life stage 4. Mean length and weight (where applicable) 5. Source 6. Diseases and treatment (where applicable) 7. Taxonomic key use for species identification
QUALITY ASSURANCE
1. Reference toxicant used routinely; source 2. Date and time of most recent reference toxicant test, test results, and current control chart 3. Dilution water used in reference toxicant test 4. Results (NOEC or, where applicable, LOEC, LC50, EC50, IC25 and/or IC50) 5. Physical and chemical methods used
RESULTS
1. Raw toxicity data in tabular form, including daily records of affected organisms in each concentration (including controls), and plots of toxicity data 2. Table of LC50s, NOECs, IC25, IC50, etc. 3. Statistical methods used to calculate endpoints 4. Summary table of physical and chemical data 5. Tabulate QA data

Figure 9-1. Summary of Minimum Laboratory Data Report Contents

SECTION 10
DATA REPORTING PROTOCOLS

All data collected as part of a Caltrans Stormwater Monitoring project are entered into the Caltrans Statewide Stormwater Database. To facilitate data management, analysis, and the comparison of results from Caltrans Districts throughout the State, a uniform system for data reporting is required for all Caltrans monitoring projects, including toxicity studies. Every fall, and periodically each spring, Caltrans distributes a Data Reporting Protocols document that describes the manner in which data should be entered into the Database. The most recent version of the Data Reporting Protocols (Caltrans, 2001), includes protocols for toxicity data, sediment data, and litter data in addition to water quality data. The data reporting protocols specific to toxicity results are presented in this section, along with general instructions for all stormwater data entered in the Caltrans Stormwater Database and the general organization of the database. These specific topics are covered in the following order:

- **General Instructions**
- **Organization of the Caltrans Statewide Stormwater Database**
- **List of Important Fields for the Toxicity Portion of the Database**
- **Overview of Toxicity Data Analysis**

GENERAL INSTRUCTIONS

Every monitoring site is assigned an ID number by Caltrans. At the beginning of each monitoring season, data reporters must contact the Caltrans database manager to receive the Site ID for each site to be sampled. Data reporters provide the name of the site, Caltrans District and constituents to be monitored. The database manager then supplies the appropriate Site IDs, or assigns them, if previously unmonitored sites are added to a project.

Standardized entries are provided for almost every field. These entries must be used exactly as presented in the Protocols (including for example specifications for spacing, hyphenation or capitalization), and attention must be given to the units specified for each constituent. If the standardized list does not contain an appropriate descriptor, the data reporter should contact the database manager prior to submitting any non-standardized entries.

The database manager will provide every data reporter with a data-reporting worksheet (Excel file format) in which all data must be submitted. All data fields should be included, even when they are left blank. Time series data (for example flow, precipitation, etc.) should be presented in a separate Excel worksheet, one for each site. For detailed instructions on how to include time series data, see Part II, Caltrans

Monitoring Protocols Guidance Manual: Water Quality (Caltrans, 2000a). For the reporting of dates and times, specific formats and references are dictated in the Protocols, as is a definition of a precipitation event. The purpose is to provide consistency in data reporting and calculation of summary statistics.

ORGANIZATION OF THE CALTRANS STATEWIDE STORMWATER DATABASE

The aquatic toxicity database is separated into four parts: Sample Description, Sampling Event Description, Site Descriptions, and Aquatic Toxicity Sample Descriptions. All four sections contain an Event ID and Monitoring Site ID field.

The Sample Description portion of the database allows for input of standard water quality information associated with the toxicity samples. These data can be instrumental in interpreting potential toxicity. The information included in this portion of the database describes the sample itself: when and how it was collected, what it was analyzed for, the method and lab used to perform the analysis, and the result of the analysis. This section also allows the data reporter to characterize the sample source, as well as the portion of a rain event that is represented by the sample.

The second part of the Database contains data that describes the precipitation event itself. This includes when the rain started and stopped, rainfall intensity, when runoff started and ended, the total amount of rainfall prior to, and during, the event, and antecedent dry days.

In the third section of the Database, the data reporter enters records that describe the site at which the sample was obtained. The fields span a range of categories from geographic information and boundaries, such as coordinates, hydrologic sub-area, land use, and size of the watershed, to political data like county, Caltrans and Regional Water Quality Control Board (RWQCB) district.

The Aquatic Toxicity Sample Description portion of the database allows the data reporter to submit information that describes the sample itself: when and how it was collected, what tests were performed, the method and lab used to perform the testing, and the test results. This section also allows the data reporter to characterize the sample source, as well as the portion of a rain event that is represented by the sample.

LIST OF IMPORTANT FIELDS WITHIN THE TOXICITY PORTION OF THE DATABASE

This section lists the data fields in the Database specific to toxicity test results. It is not meant to reproduce the Protocols, but simply to give the reader an idea of the type of information that is required from data reporters.

The Sample Description section for the toxicity portion of the database differs significantly from the Sample Description portion of the water quality database. Although some of the fields are the same (e.g. event identification, site identification, sample start and end time and date, collection method, etc.) several additional fields have been added. Database fields specific to toxicity test results include information such as test organism, test type, result type, observed statistically significant differences, whether or not TIEs were performed, and if TIEs successfully identified toxic constituents. The specific data fields included in the Sample Description section of the toxicity portion of the database are presented in the example spreadsheet included as Figure 10-1. Examples of data that may be entered into each of the data fields are also included in Figure 10-1.

The Sampling Event description section is identical to the water quality portion of the database which includes such fields as the Rain Start Time, Rain End Time, Rain Start Date, Rain End Date, Event Rain, Max Intensity, Total Flow Volume, Peak Flow and the Estimated % Capture, as well as who collected the sample.

The Site Description portion is also identical to the water quality database fields, which include the Caltrans District, County, RWQCB, Latitude, Longitude, Land Use, Catchment Area, Impervious Fraction, Post Mile, Receiving Water Type, Time Series, and Site Description.

OVERVIEW OF TOXICITY DATA ANALYSIS

Toxicity data can be expressed and reported in several ways. This section provides an overview of acute and chronic toxicity data analysis and the ways in which toxicity data are reported. The possible result types for each toxicity test method are presented in Table 10-1.

Acute Toxicity Data Analysis

Analysis of acute toxicity data will depend on the type of test that is conducted (i.e. screening level or dilution series, see ***Section 4***). For screening level tests, results are analyzed by hypothesis testing. Hypothesis testing in this case is used to determine if survival in the sample is significantly different from control survival. For tests with a dilution series, results may be analyzed by hypothesis testing or used to determine a lethal concentration$_{50}$ (LC_{50}) or other point estimate (e.g. LC_{10}, LC_{25}). An LC_{50} refers to an estimate of the concentration that is lethal to 50 percent of the test organisms. U.S. EPA guidance describes four possible methods for estimating the LC_{50} including the Graphical Method, Spearman-Karber Method, the Trimmed Spearman-Karber Method, and the Probit Method. The requirements, description of calculations involved or computer program used, and an example of the calculations for each of these methods are described in U.S. EPA (1993) guidance. Hypothesis testing for dilution tests is conducted to determine the No Observed Effect Concentration (NOEC). An NOEC represents the highest measured concentration of a sample or toxicant that causes no statistically significant adverse effect on test organisms.

Results may also be reported in toxic units (TU). The toxic unit for an individual acute toxicity test (TUa) or chronic toxicity test (TU_c) is calculated by taking the reciprocal of the sample dilution that causes the effect (i.e. the LC_{50}, LC_{25}, or NOEC) by the end of the acute exposure period. An example TU calculation is illustrated below:

$$TU = \frac{\text{highest sample concentration tested (100\%)}}{LC_{50},\ LC_{25},\ \text{or NOEC}}$$

Chronic Toxicity Data Analysis

Chronic toxicity tests measure lethality as well as other endpoints including reproduction for *Ceriodaphnia dubia*, growth for *Pimephales promelas*, and cell growth for *Raphidocelis subcapitata*. Statistical analysis for each of these tests is described below.

Ceriodaphnia dubia

Point estimation techniques are used to determine the EC_{25}, EC_{50} (EC values represent the estimated concentration that effects survival of a certain percentage (25, 50, etc.) of test organisms), and LOEC and NOEC values for survival and reproduction are obtained using a hypothesis test approach such as Fisher's Exact Test, Dunnett's Procedure, or Steel's Many-one Rank Test. Separate analyses are performed for the estimation of the LOEC and NOEC endpoints and for the estimation of EC_{25}, and EC_{50}.

The response used in the statistical analysis for survival is the number of animals surviving at each test concentration. Concentrations at which there is no survival in any of the test chambers are excluded from the statistical analysis of the NOEC and LOEC for reproduction, but included in the estimations of the EC_{25} and EC_{50}. The response used in the analysis for reproduction is the number of young (neonates) produced per adult female, which is determined by taking the total number of young produced until either the time of death of the adult or the end of the experiment, whichever comes first. An animal that dies before producing young, if it has not been identified as a male, would be included in the analysis with zero entered as the number of young produced. The subsequent calculation of the mean number of live young produced per adult female for each toxicant concentration provides a combined measure of the toxicant's effect on both mortality and reproduction.

Table 10-1. Summary of Result Types for Acute and Chronic Toxicity Tests

Test Method	Endpoint(s) Tested	Result Types (units)	
Test Type		**Screening Level**	**Dilution Series**
Acute *Ceriodaphnia dubia, Pimephales Promelas,* and *Oncorynchus mykiss*	Mortality	• Mean mortality (%) • Statistically significant difference from control (yes/no) • Standard error (%)	• Mean mortality (%) • Standard error (%) • LC_{50} (% dilution) • NOEC/LOEC (% dilution) • Acute Toxic Units (TUa)
Chronic *Ceriodaphnia dubia, Pimephales promelas*, and *Oncorynchus mykiss*	Mortality	• Mean mortality (%) • Statistically significant difference from control (yes/no) • Standard error (%)	• Mean mortality (%) • Standard error (%) • LC_{50} (% dilution) • NOEC/LOEC (% dilution) • Chronic Toxic units (TUc)
Chronic *Ceriodaphnia dubia*	Reproduction	• Mean reproduction (neonates/adult) • Statistically significant difference from control (yes/no) • Standard error (neonates/adult)	• Mean reproduction (neonates/adult) • Standard error (neonates/adult) • $EC_{50,}$ EC_{25} etc. (% dilution) • NOEC/LOEC (% dilution) • Chronic Toxic units (TUc)
Chronic *Pimephales promelas*	Growth	• Mean growth (mg/individual) • Statistically significant difference from control (yes/no) • Standard error (mg/individual)	• Mean growth (mg/individual) • Standard error (mg/individual) • $IC_{50,}$ IC_{25} etc. (% dilution) • NOEC/LOEC (% dilution) • Chronic Toxic units (TUc)
Chronic *Selenastrum capricornutum*	Growth (cell number)	• Mean growth (cells/mL) • Statistically significant difference from control (yes/no) • Standard error (cells/mL)	• Mean growth (cells/mL) • Standard error (cells/mL) • $IC_{50,}$ IC_{25} etc. (% dilution) • NOEC/LOEC (% dilution) • Chronic Toxic units (TUc)

Pimephales promelas

Point estimation techniques are used to determine the LC_{50}, IC_{25}, and IC_{50} values . Lowest observed effect concentration (LOEC) and NOEC values for survival and growth are obtained using a hypothesis testing approach such as Dunnett's Procedure or Steel's Many-one Rank Test. Separate analyses are performed for the estimation of the LOEC and NOEC endpoints and for the estimation of LC_{50}, IC_{25}, and IC_{50}.

The response used in the statistical analysis of survival is the number of animals surviving at each test concentration. Concentrations at which there is no survival in any of the test chambers are excluded from statistical analysis of the NOEC and LOEC, but included in the estimation of IC and LC endpoints. The response used in the statistical analysis of growth data is mean dry weight per replicate. An IC estimate can be calculated for the growth data via point estimation techniques. Hypothesis testing can be used to obtain the NOEC for growth. Concentrations above the NOEC for survival are excluded from the hypothesis test for growth effects.

Selenastrum capricornutum

The IC_{25} and IC_{50} are calculated using the point estimation techniques, and LOEC and NOEC values for growth are obtained using a hypothesis testing approach such as Dunnett's Procedure or Steel's Many-one Rank Test. Separate analyses are performed for the estimation of the LOEC and NOEC endpoints and for the estimation of IC values.

The response used in the statistical analysis for this test is the number of cells per milliliter per replicate.

Sample ID	Treatment	Test Type	Sample Date	Test start date	Test end date	Test organism	Parameter	Result Type	Units	Num Qual	Result	Statsig	Test Day	TIE performed	Suspect Toxicant(s)	TIE Phase Completed
CT-1	none	acute	4/30/02	5/1/02	5/3/02	*C.dubia*	mortality		%		30		2	no	no	I
CT-1	100 ppb PBO	acute	4/30/02	5/1/02	5/3/02	*C.dubia*	mortality	signif.	yes/no		no	no	2			
CT-10	none	chronic	8/6/02	8/7/02	8/14/02	*P. promelas*	growth	NOEC	%	<	6	yes	7	yes	copper	III
CT-10	none	chronic	8/6/02	8/7/02	8/14/02	*P. promelas*	growth	signif.	yes/no			yes				

Figure 10-1. Example of Toxicity Data Fields

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APPENDIX A
TOXICITY IDENTIFICATION EVALUATIONS (TIEs)

This appendix provides specific information on TIE manipulations. Text was extracted , with a few modifications, from the technical report developed by Kinnetic Laboratories, Inc. for Caltrans (Caltrans, 1999b). Information presented in this write-up is based on an extensive review of the available runoff toxicity data (Caltrans, 1999c). The purpose of this appendix is to provide background information on TIEs and to outline, as an example **ONLY,** the TIE methods that may be appropriate for stormwater samples. This information is included to simply illustrate that TIEs for stormwater samples is a complex process and adjustments can be made based on the expertise and best professional judgement of the toxicity testing personnel. It is not the intent of this appendix to lay out the specific methods that should be followed for TIEs conducted for Caltrans toxicity studies.

TIEs

TIEs seek to identify toxiciants in a sample via a series of manipulations and associated bioassays which target a systematically narrowing list of suspect toxicants. Each manipulation is designed to identify a particular toxicant group by altering it or rendering it biologically unavailable. A series of EPA publications developed since 1988 by the EPA Environmental Research Laboratory - Duluth, MN form the basis for the TIE methodologies (U.S. EPA 1991, 1993b, 1993c). Three Phases comprise a full TIE:

Acute (lethality) or chronic tests can be used during the TIE characterizations. Final analysis of results compare endpoints (e.g. 96-hour LC_{50}s) from manipulated samples to those of an unaltered effluent baseline. Freshwater bioassay test species include the water flea *Ceriodaphnia dubia*, fathead minnow (*Pimephales promelas*) or alga (*Selenastrum capricornutum*).

Phase I (the Characterization phase) is aimed at developing information on the general chemical class of a contaminant (e.g. metals, non-polar organics, volatile compounds or pH-sensitive toxiciants) causing the toxicity (U.S. EPA, 1991). In this Phase, a toxic effluent is subjected to a series of chemical manipulations including pH adjustment, aeration, filtration, C_{18} (SPE) column extraction, chelation with EDTA, reduction of oxidants and evaluation of pH-dependent toxicity. Following each of the chemical manipulations, bioassays are performed to evaluate whether the toxicity has been reduced or eliminated.

The original EPA Phase I TIE procedures were designed for the characterization of municipal and industrial effluents (POTWs). However, since stormwater runoff is not likely to contain significant amounts of either chlorine or ammonia (expected in POTWs), and since prior TIEs of regional stormwaters have shown that evidence for a volatile toxicant has always correlated with evidence of a non-polar organic toxicant, we have

developed an abbreviated subset of the EPA procedures for stormwater samples. The graduated pH test, the oxidant-reduction test and the pH-adjustment test (to acid and alkaline extremes within each manipulation) have been eliminated from the Phase I TIE procedures. The toxicant groups targeted therefore are volatile or oxidizable compounds, particulate-bound toxins, cationic metals, non-polar organics, and organophosphates:

- Aeration of the sample sparges volatiles and will also oxidize some compounds.

- Filtration identifies the extent to which sample toxicity is affected by particulates, particulate-bound toxicants or compounds in suspension.

- C_{18} SPE uses a sorbent column to evaluate the contribution to sample toxicity of non-polar organic compounds and certain metals or metal chelates. Non-polar compounds are trapped in the column through solubility and polarity interactions with the C_{18}.

- EDTA reduces sample toxicity by chelation of certain cationic metals. For Ceriodaphnia EDTA chelation has been shown to effectively remove or reduce the toxicity of Cd^{++}, Cu^{++}, Pb^{++}, Mn^{++}, Ni^{++}, and Zn^{++}. If cationic metals are present in the sample, toxicity should be diminished by small additions of EDTA but may be increased by larger additions, due to toxicity of the EDTA itself.

- Piperonyl Butoxide (PBO) blocks the action of metabolically-activated organophosphate compounds (OP pesticides). The addition of PBO therefore reduces toxicity of samples containing Ops. PBO however, also enhances the toxicity of pyrethroid insecticides.

At the Phase I level of testing, relatively small sample sizes and limited replications make statistical inferences difficult. Often 95% confidence limits on LC_{50} values are not calculable, and thus the statistical significance of substantial changes in post-manipulation toxicity may not be possible to establish. This is especially true in cases of samples with low to moderate initial 96h toxicity (LC_{50} >50%). Therefore, considerable latitde must be given when interpreting the results of Phase I TIEs.

Phase II (the Identification Phase) is designed to identify specific toxicants within the toxicant class or classes implicated during the Phase I testing (U.S. EPA, 1993b). The complexity of Phase II is heavily dependent upon which toxicant classes have been implicated. For example, if Phase I has indicated a metal toxicant, then Phase II less difficult. The test effluent is analyzed for metals content, and the analytical results compared with available metals toxicity criteria data for the test species used. If non-polar organic compounds are suspected, Phase II is considerably more complex. The effluent is subjected to a series of SPE and HPLC fractionations, concentration and toxicity testing, combined with GC/MS or other analysis until particular toxicants are identified and quantified. Each step in the series is designed to narrow the possible

suspects; then, based on the quantitative analytical identifications, the toxicity results are compared with the known dose-responses of the short-list of suspects.

Phase II Non-Polar Organics

Our procedures follow those of EPA (U.S. EPA, 1993b), but also draw heavily on Bailey, et al. (1996). The approach is one of successive steps of fractionation, methanol elution and concentration, each followed by toxicity tests and chemical analyses until suspect toxicants are identified and compared with toxicity values. The following paragraphs summarize the methods employed during Phase II non-polar organic investigations.

- HPLC Fractionation. MEOH fractions which demonstrate toxicity, and their corresponding MEOH blank fractions are further concentrated, then fractionated using High Performance Liquid Chromatography (HPLC). For each sample, this produced a total of 30 concentrated (615x-666x) subfractions which are tested for toxicity.

- pH adjustments. Whole sample is adjusted to pH 3 and pH 11, using HCl and NaOH. Adjusted sample is held for 6 h, then re-adjusted back t o initial pH_i. Toxicity testing is then conducted on the two adjusted/re-adjusted samples.

- Analytical Chemistry. The original (unmanipulated) samples are extracted and analyzed by GC or GC/MS for suspect organic toxicants. The HPLC fractions are also analyzed by these methods.

Phase II Metals

The EPA Phase II approach for the identification of suspect metals toxicants include a suite of procedures based initially on analysis for metals in the sample, and comparison of the metals analysis data with the sample toxicity test results and with published metals toxicity information. Comparisons are made with published toxicity-based water quality criteria (SFBRWQCB, 1991 and U.S. EPA, 1993a), and to species-specific metals toxicities [(e.g. Ceriodaphnia (Schubauer-Berigan et al. 1993)]. Ion-exchange resins have also been used to provide supporting evidence for identifying the cause of toxicity in effluents (U.S. EPA, 1993b).

Phase II Volatiles, Oxidizables, Surfactants

To test for Contributions of volatile, oxidizable or surfactant compounds to toxicity, aliquots of original sample are aerated with air and with nitrogen, then toxicity tested. Aliquots are also created from rinsate of the aeration container walls, which may harbor surfactants from the sample.

Phase III (the Confirmation Phase) serves to verify the conclusions reached in Phase II by repeating the critical Phase II work with elevated levels of QA/QC during the testing process (U.S. EPA, 1993c). Phase III can, in some ways, be a formality, since some confirmation steps are inherent in the Phase II treatments. There may be no real "boundary" between Phase II and Phase III. Therefore, the Toxicity Confirmation Procedures (Phase III) manual is written as a series of "approaches" to the problem of toxicity confirmation; e.g. the correlation approach, the symptom approach, the species sensitivity approach, the spiking approach, and the mass balance approach. The final choice of our approach(es) to the confirmation task depends, in many ways, on the results of Phase II.

APPENDIX B

The *2001-2002 Toxicity Data Reporting Protocols* can be found in the Data Reporting section of this manual.

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SECTION 2.1

Caltrans Data Reporting Protocols: Stormwater

NOVEMBER 2003

Caltrans Monitoring and
Water Quality Research Program

2003-2004 Stormwater Quality Data Reporting Protocols

CTSW-RT-03-095.51.42

Prepared for:
California Department of Transportation
Environmental Program

GENERAL INSTRUCTIONS

Please read and be familiar with these general instructions. Water quality data can only be accurately and expediently incorporated into the Caltrans Master Stormwater Database if these instructions are carefully followed. Adhering to these instructions will facilitate the processing of data and eliminate the need for time-consuming "record-by-record" data validation at year's end.

- **Get Monitoring Site IDs from Caltrans at the beginning of each monitoring season.**

  Caltrans will assign the "Monitoring Site ID" for all monitoring sites. All Caltrans data reporters are required to contact the Caltrans database manager (Mike Trouchon – Larry Walker Associates) at the **beginning** of each sampling season to receive Monitoring Site IDs for each new site they will sample. Note that BMP sites having multiple points of collection (e.g., inlet, within, outlet, bypass, overflow, etc.) will be assigned a unique Monitoring Site ID for each point of collection. Data reporters shall provide the database manager with the name of each site, the type of monitoring to be performed, and the Caltrans district in which each site resides.

- **Enter data appropriately.**

  To facilitate the accurate entry of water quality data into Excel worksheets or Access data tables by Caltrans data reporters, and the subsequent transfer of this data into the Caltrans Master Stormwater Database, each data field described in this data-reporting protocol document possesses the following attributes: Field Name, Field Type, Field Size, Example, Definition, Notes (where applicable), Standard List (where applicable) and Alternate Value (where applicable). These eight data field attributes are defined below.

Field Name	Name of data field as it appears in the Excel worksheet or Access data table used for data reporting.
Field Type	Specifies the type of data, text or numeric that can be stored in a data field. Note: text fields can store both text and numbers.
Field Size	Specifies the number of characters that can be stored in a text field or the number of decimal places required of a number entered into a numeric field.
Example	Provides an example of the data type and possible value that is appropriate for a specific data field.
Definition	Provides a definition of the data type and possible value that is appropriate for a specific data field.
Notes	Provides further information that may be helpful in appropriately and accurately populating a specific data field.
Standard List	Provides a list of standard values appropriate for populating a specific data field.
Alternate Value	Specifies if the use of "N/A" (not applicable) or "None" is an appropriate value for a specific data field.

GENERAL INSTRUCTIONS (CONTINUED)

Additionally, the following rules should be abided by when entering water quality data into either Excel worksheets or Access data tables.

- **Select and enter text values only from the "Standard List"** of values provided for each data field. Standardized values must be entered exactly as specified. Standard lists are included with the description of each data field where appropriate. If a standardized value provided for a particular data field does not accurately describe the data to be entered into that field, please contact the Caltrans database manager to discuss the creation of an additional value for a particular data field.

- **Use "Constituent" names exactly as they appear in the standardized constituent list, and report data in the units specified.** Please refer to Section 4 at the end of these protocols for the list of "Standard Constituent Names".

- **Enter numeric data values according to the definition provided for the particular numeric data field.** Text must not be entered into numeric data fields. Text-based comments regarding a numeric value should be placed in the "Notes" data field.

- **"Mobilization ID" follows the format YYYY-Some combination of text and/or numbers** ("Year monitoring season begins-Unique string of text and/or numbers that signify to the data provider a specific storm event that occurred at a particular monitoring site"). Mobilization IDs for the 2003-2004 Caltrans monitoring season would all begin with "2003".

- **Use the correct system for date entries when using Microsoft Excel.** Dates must be entered using the Excel "1900 Date System" typical for Windows (the "1900 Date System" is the default date system used by Microsoft Excel installed on computers running a Windows operating system). The "Macintosh 1904 Date System" should be switched off in Excel preferences (located in the following nested menus: Tools >> Options >> Calculation). Data providers managing their data exclusively in Microsoft Access need not address this issue.

- **Values contained in data fields that link records from one Excel worksheet or Access table to another, such as Monitoring Site ID and Mobilization ID, must match exactly** for the correct relationship to exist between records once the data is imported into the Caltrans Master Stormwater Database (Version 2.0 built using Microsoft Access 2000). No match can be made between a Monitoring Site ID of "7 –21" (note an extra space between the 7 and the hyphen) found in the Site Descriptions worksheet or data table and a Monitoring Site ID of "7-21" found in the Sample Descriptions worksheet or data table. In general, wherever data field entries are hyphenated, do not include spaces.

- **If any cell in a data field is left blank* (i.e., the data cell is null), a brief note explaining why the data cell was left blank must accompany the particular record.** The brief note shall be placed in the "Notes" data field associated with the particular record containing one or more blank data cells.

  *Exception – The following data field can contain null values without an associated note entered in the "Notes" data field of the relevant worksheet or data table:

Excel Worksheet or Access Table	Data Field
Sample Descriptions	Overall Qualifier

- **The use of "N/A" as a value entered into a text data field is acceptable for some fields** where the data field definition does not apply to the particular data record being entered. For example, the data field "Control Site" (found in the Site Descriptions worksheet) applies only to Caltrans BMP sites for which a control site exists. This data field is "not applicable" to a non-BMP monitoring site with a "Point of Collection" equal to "Discharge". Data fields where the use of "N/A" is acceptable have this data value option specified in the Alternate Value attribute. "N/A" cannot be entered into a numeric data field. ***Additionally, the use of the value "Other" is not acceptable for any data field.***

- **Make sure that all required data records for a particular sampling event exist in the Sample Descriptions, Sampling Event Descriptions and Site Descriptions worksheets or data tables according to the following rules used to maintain referential integrity among all related records:**

  - A Monitoring Site ID value (e.g., 7-21) contained in the Sample Descriptions worksheet or data table must be represented by a single record for the same Monitoring Site ID in the Site Descriptions worksheet or data table.

  - A Monitoring Site ID value (e.g., 7-21) contained in the Site Descriptions worksheet or data table must be represented by at least one record in the Sample Descriptions worksheet or data table.

  - A unique combination of Monitoring Site ID (e.g., 7-21) and Mobilization ID (e.g., 2003-01) contained in the Sample Descriptions worksheet or data table must be represented by a single record for the same unique Monitoring Site ID/Mobilization ID pair in the Sampling Event Descriptions worksheet or data table. Do not forget to create an Event Descriptions record for "non-storm" monitoring events (such as dry weather sampling, groundwater sampling, etc.) even though these events may not include the collection of precipitation and runoff data (Mobilization ID, Site ID, Event Type, Sample Collector, Organization and Event Notes can be populated for these non-storm event records).

  - A unique combination of Monitoring Site ID (e.g., 7-21) and Mobilization ID (e.g., 2003-01) found in the Sample Event Descriptions worksheet or data table must be represented by at least one record in the Sample Descriptions worksheet or data table having the same Monitoring Site ID/Mobilization ID pair.

- **Do not report analytical results for blanks, duplicates, or other QA/QC samples. Report only values from environmental samples that have been QA/QC'ed.**

GENERAL INSTRUCTIONS (CONTINUED)

- **Submit Caltrans data exactly in the format specified by these data-reporting protocols.**

  All Caltrans "Electronic Data Deliverables" (EDD) must be submitted in the format described in this document. All Excel worksheets or Access data tables submitted by data providers must be formatted according to the requirements of the data fields contained within them as described in this data-reporting protocols document. The **LDC Laboratory EDD Error Checker and Automated Data Validation software** will export **Sample Descriptions** data in the format specified by this document. Each data reporter must enter **Sampling Event Descriptions** and **Site Descriptions** data in their respective Excel worksheets or Access data tables by hand. Before submitting an EDD to the database manager, please confirm that all data entered in either a column (for Excel worksheets) or data field (for Access data tables) are appropriate for that particular field.

- **If a sample is analyzed and subsequently deemed not to be representative of the monitoring event from which it was collected (e.g., the sample doesn't meet the requirements for percent storm capture, minimum number of aliquots, etc.), then the data should not be included as part of the data reporter's EDD.**

  Furthermore, if individual records or complete monitoring events are deemed invalid or unrepresentative at the end of the monitoring season, and hence excluded from analysis and discussion in a contractor's final monitoring report, then the Caltrans database manager (Mike Trouchon – Larry Walker Associates) must be notified to remove these same invalid or unrepresentative data from the Caltrans Master Stormwater Database.

- **Label all elements of each Electronic Data Deliverable (EDD) clearly**

  - The Excel workbook file or Access database file containing Sample Descriptions, Sampling Event Descriptions, and Site Descriptions data should be labeled with the name of the data reporter (contractor or university), the title of the Caltrans activity under which the data was collected, and the monitoring season (e.g., 2003-2004 or 03-04) during which the data were collected.

    File naming convention for water quality data:

Water quality data file	URS RVTS Study_2003-2004
	UCLA First Flush Study_03-04

  - The submittal of supporting data and documents, such as time series data, hydrographs, maps, and photographs, should be labeled with the Caltrans Monitoring Site ID and monitoring season to which they correspond. Times series data collected during storm events at a monitoring site can be submitted as multiple worksheets (one worksheet for each monitored storm event) in a single workbook that represents all times series data collected at that site during an entire monitoring season. Additionally, all hydrographs (produced by the **Caltrans Hydrologic Utility**) generated from time series data should be included as individual labeled worksheets within the workbook containing all times series data collected at a particular site over the course of the monitoring season.

File naming conventions for supporting data:

Time Series & Hyrdrograph file	Site 7-21 Time Series_2003-2004.xls
Map file	Site 7-21 Map_2003-2004.pdf
Photograph file	Site 7-21 Photo_2003-2004.jpeg

- When submitting an EDD to the Caltrans database manager, please compile all files (water quality data, including sample, event and site descriptions, time series data and hydrographs, maps and photographs) onto one or more recordable compact discs (CD-R) labeled with the data reporter's name and date of data submittal. Mail CD(s) to the database manager at the address provided below.

- **Please notify Caltrans of any errors or inconsistencies found in this document, or any changes you might recommend.**

Definition of a Precipitation Event

For the purposes of these protocols, a precipitation event shall begin with six consecutive hours during which a sum total of at least 2.54 mm (0.1 inches) of rain falls, and end with six consecutive hours in each of which no rainfall greater than 0.25 mm (0.01 inches) of rain is recorded. The precipitation event so identified shall be truncated so that it both begins and ends in hours with rainfall equal to or greater than 0.25 mm (0.01 inches).

Contact Information

Please refer questions or comments to:

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1. WATER QUALITY SAMPLE DESCRIPTIONS

1.1. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-21
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located. Monitoring sites in a given Caltrans District numbered between 1 and 9 must be reported with a 0 (zero) in their Monitoring Site IDs (e.g., 7-09, as opposed to 7-9).

1.2. Mobilization ID

Field Type: Text
Field Size: 20 characters
Example: 2003-01
Definition: A unique, site-specific identification code assigned to the mobilization effort for a particular sampling event that occurred at a particular monitoring site.
Notes: Mobilization ID follows the format YYYY-Some combination of text and/or numbers ("Year monitoring season begins-Unique string of text and/or numbers that signify to the data provider a specific storm event that occurred at a particular monitoring site"). Even if a site isn't monitored until the latter half of the monitoring season (e.g., Site X is monitored during Feb. – Apr. 2004 – the latter half of the 2003-2004 monitoring season), its Mobilization IDs include the year in which the general Caltrans monitoring season began (i.e., Mobilization IDs for samples collected at Site X would all begin with "2003").

1.3. Sample Start Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which composite sampling begins or grab sample is collected. In regard to composite samples, specifically the date on which the sampler was activated <u>and</u> the flow meter began totalizing flow.
Notes: Formatted as mm/dd/yyyy.

1.4. Sample Start Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which composite sampling begins or grab sample is collected. In regard to composite sampling, specifically the time at which the sampler was activated <u>and</u> the flow meter began totalizing flow.
Notes: Formatted for 24-hour clock (hh:mm).

1.5. Sample End Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which composite sampling ends. Specifically, the date on which the last composite sample aliquot was collected.
Notes: Formatted as mm/dd/yyyy.

1.6. Sample End Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which composite sampling ends. Specifically, the time at which the last composite sample aliquot was collected.
Notes: Formatted for 24-hour clock (hh:mm).

1.7. Sample Source

Field Type: Text
Field Size: 20 characters
Example: Storm
Definition: Identifies the source of the water quality sample analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Storm - Sample from storm water (rainfall) runoff
- Rain - Sample from rainwater collected directly from the atmosphere
- Snowfall - Sample from snowfall collected directly from the atmosphere
- Snow melt - Sample from snow melt runoff
- Receiving - Sample from receiving water
- Groundwater - Sample from groundwater
- Non-storm - Sample from non-storm water runoff

1.8. Event Representation

Field Type: Text
Field Size: 20 characters
Example: FF
Definition: Describes the part of the event represented by the sample.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- FF - Event first flush
- Peak - Event peak flow
- Whole - Whole storm
- Discrete - One or more discrete samples collected during an event that cannot be described as representing the first flush, peak or whole storm portion of the event. This value will typically, although not exclusively, be used for a sample record having a Sample Source value equal to "Non-storm".
- Snow Melt Comp - Used to describe a composite sample collected from snow melt runoff.
- X-hr Comp - Used to describe a planned composite sampling event lasting X hours. Data provider to note duration of composite sampling when populating this data field (e.g.,"8-hr Comp")

1.9. Sample Type

Field Type: Text
Field Size: 1 character
Example: C
Definition: Describes the way in which sample was collected.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- C - Composite Sample: A sample made up of multiple sub-samples (aliquots) collected over some spatial or temporal scale.
- G - Grab Sample: A single sample that represents conditions at a distinct point in time. All grab samples should be reported with Sample Start Date and Sample Start Time values equal to their Sample End Date and Sample End Time values.

1.10. Sample Matrix

Field Type: Text
Field Size: 10 characters
Example: Water
Definition: Matrix from which sample was analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Water

Note: Other sample matrices, such as sediment, sludge, soil, solid, etc. are now addressed in the 2003-2004 Particle-Sediment Data Reporting Protocols document.

1.11. Constituent Type

Field Type: Text
Field Size: 4
Example: CON
Definition: Describes the type or class of constituent analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- CON - Conventionals
- HC - Hydrocarbons
- ION - Major Ions
- M - Metals
- MIC - Microbial
- MIN - Minerals
- N - Nutrients
- PCB - Polychlorinated Biphenyls (PCBs)
- PEST - Pesticides
- SVOC - Semi-volatile Organic Compounds
- VOC - Volatile Organic Compounds
- MISC - Miscellaneous Constituents (refer to Section 4, "Standard Constituent Names", for list of constituents classified as "Miscellaneous").

1.12. CAS Number

Field Type: Text
Field Size: 15 characters
Example: 7440-50-8
Definition: CAS Number (Chemical Abstracts Service Registry Number) or Caltrans Constituent ID number for constituent.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Refer to Section 4, "Standard Constituent Names", for list of CAS and Caltrans Constituent ID numbers.

1.13. Constituent

Field Type: Text
Field Size: 40 characters
Example: Cu
Definition: Name of constituent as found in the Caltrans Master Stormwater Database.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Refer to Section 4 – "Standard Constituent Names".

1.14. Fraction

Field Type: Text
Field Size: 6 characters
Example: Total
Definition: Describes fraction of constituent analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager. From the operational perspective, the **Total** and **Total Recoverable** fractions describe an **unfiltered** or whole water sample, whereas the **Dissolved** fraction describes a **filtered** sample (typically filtered through a 0.45 micron filter). "N/A" is the default value used to describe the fraction of a constituent analyzed from an unfiltered or whole water sample for which fraction distinctions are typically not made (e.g., most conventional constituents, hydrocarbons, volatile and semi-volatile organic compound, etc.).

Standard List

- Total - Total fraction (used for all metals, hardness, potassium, barium, manganese, ammonia (NH3-N), orthophosphate, phosphorus and TKN).
- TR - Total recoverable fraction (used for metals only).
- Diss - Dissolved fraction (used for all metals, hardness, potassium, barium, manganese, ammonia (NH3-N), orthophosphate, phosphorus and TKN),
- N/A - All constituents other than those specified above should receive a value of "N/A" (not applicable) to describe their fraction analyzed.

1.15. Numerical Qualifier

Field Type: Text
Field Size: 1 character
Example: <
Definition: An indication of what the Reported Value for an analyzed sample represents (i.e., a minimum, maximum or "exact" value).
Notes: Standardized Entry. Select value from standard list or contact database manager. Please refer to Overall Qualifier (see data field 1.17. below) for additional guidance on the appropriate qualification of water quality results.

Standard List

- < - Actual value of analyzed sample is less than reported value. This symbol must be used for all "non-detect" samples.
- = - Value of analyzed sample is as reported.
- > - Actual value of analyzed sample is greater than reported value.

1.16. Reported Value

Field Type: Numeric
Field Size: N/A
Example: 0.25
Definition: Reported laboratory result of analyzed sample.
Notes: Reported Value must equal Reporting Limit if associated Numerical Qualifier is "<".

1.17. Overall Qualifier

Field Type: Text
Field Size: 6 characters
Example: U
Definition: An overall data validation qualifier based on lab results and associated quality assurance/quality control (QAQC) analyses.
Notes: Standardized Entry. Select value from standard list or contact database manager. The qualifiers and definitions presented below represent a compilation of data qualifiers used by specific EPA programs as noted in: (1) *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 1994); and (2) *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999).

Standard List

- U - The material was analyzed for, but was not detected above the level of the associated value (the associated value represents a reporting limit that may or may not be elevated due to blank contamination).
- J - The associated value is approximate (i.e., an estimated quantity).
- N - The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification".
- NJ - The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
- UJ - The material was analyzed for, but was not detected. The associated value (i.e., reporting limit) is an estimate and may be inaccurate or imprecise.
- R - The sample result is rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Notes: While data reporters may include "rejected" data (data assigned an Overall Qualifier value of "R") in the EDDs they provide to the Caltrans database manager, these data are not imported into the Caltrans Master Stormwater Database at the end of each monitoring season.

1.18. Units

Field Type: Text
Field Size: 12 characters
Example: mg/L
Definition: Describes the unit of measure associated with the Reported Value.
Notes: Standardized Entry. Select value from standard list or contact database manager. Report sample results in the appropriate unit associated with a particular constituent as specified in "Standard Constituent Names" (see Section 4). Use capital "L" for liter abbreviation. Confirm that values for Reported Value, Method Detection Limit, and Reporting Limit are all reported in the same units for individual sample records.

Standard List

- ug/L
- mg/L
- fibers/L - Unit to be used only when reporting analytical results for Asbestos.
- °C
- pH units
- umhos/cm
- MPN/100mL
- NTU

1.19. Preparation Method

Field Type: Text
Field Size: 40 characters
Example: Separatory Funnel
Definition: Describes the preparation a sample underwent prior to analysis. All samples receiving no form of preparation prior to analysis should have this data field value reported as "None".
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Hot Plate
- Microwave
- Purge and Trap
- Methanol Extraction
- Continuous
- Separatory Funnel
- Soxhlet
- Ultrasonic Extraction
- Solid Phase Extraction - for water samples
- Accelerated Solvent Extraction

Alternate Value: - None (see Definition above).

1.20. Method Reference

Field Type: Text
Field Size: 12 characters
Example: EPA
Definition: Provides the reference for the analytical method used to evaluate the sample.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- EPA - US Environmental Protection Agency.
- SM - Standard Methods.
- Field Probe - Constituent evaluated in the field using a self-contained analytical instrument. Note: no Method Numbers are associated with field-measured constituents.
- Caltrans - Caltrans-defined analytical method.

1.21. Method Number

Field Type: Text
Field Size: 16 characters
Example: 625
Definition: Reference number for the analytical method used to evaluate the sample.
Notes: By convention, method numbers that contain a text suffix do not include a space between the number and the text suffix (e.g., 8141A).

Alternate Value: - N/A (appropriate to use this value when Method Reference value is equal to "Field Probe").

1.22. Method Detection Limit

Field Type: Numeric
Field Size: N/A
Example: 0.2
Definition: Method Detection Limit (MDL) – The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from the analysis of a sample in a given matrix containing the analyte.
Notes: Concentrations reported by a laboratory that are between the MDL and Reporting Limit (see data field 1.23. below) are usually flagged by the laboratory as estimated "J", indicating that the constituent is present but its concentration cannot be accurately quantified (see data field 1.17, Overall Qualifier, for further information on data validation qualifiers).

1.23. Reporting Limit

Field Type: Numeric
Field Size: N/A
Example: 1.0
Definition: Reporting Limit (RL) as reported by laboratory. This value is the lowest concentration of a constituent that can be reliably quantified within specified limits of precision and accuracy during routine laboratory operating conditions. Reporting Limit is equivalent to Practical Quantitative Limit (PQL) and Reported Detection Limit (RDL).
Notes: The RL may be elevated above the Caltrans "target" RL due to matrix interference.

1.24. Collection Method

Field Type: Text
Field Size: 6 characters
Example: Auto
Definition: Describes the way in which a sample was collected.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Auto - Sample aliquot collected by automated sampling device.
- Manual - Sample aliquot collected manually.

1.25. Field Sample ID

Field Type: Text
Field Size: 35 characters
Example: 134-0010-281500A
Definition: Field identification number assigned to sample/sample vessel.
Notes: This data field can contain any combination of text and numeric characters.

1.26. Lab Name

Field Type: Text
Field Size: 25 characters
Example: APPL
Definition: Name of laboratory that analyzed sample.
Notes: Standardized Entry. Select value from standard list. The list of analytical laboratories used by the Caltrans Storm Water Management Program will likely change over time, and therefore the Standard List below might not include the name of every laboratory used in any given monitoring year. If the name of a laboratory used to analyze samples does not appear in the list below, simply report the name of the laboratory in this data field. The database manager will notice the new laboratory name during routine data validation and will add it to the Standard List below in a subsequent version of this document.

Standard List

- APPL - Agriculture & Priority Pollutants Labs
- Aquascience
- Associated Labs
- BSK
- CEL - Calscience Environmental Labs
- DMA - Del Mar Analytical
- Field Analysis - Use this value for field-measured parameters where Method Reference = "Field Probe"
- Frontier - Frontier Geosciences
- GeoAnalytical Labs
- Kinnetics
- North Coast Labs
- Pat-Chem
- Quanterra
- Silliker
- Soil Control Lab
- ToxScan
- UCLA

1.27. Lab Sample ID

Field Type: Text
Field Size: 25 characters
Example: 120085-400A
Definition: Laboratory identification number assigned to sample by analytical laboratory.
Notes: This data field can contain any combination of text and numeric characters.

1.28. Contract Number

Field Type: Text
Field Size: 12 characters
Example: 43A005
Definition: Caltrans contract number under which sample was collected.
Notes: This data field can contain any combination of text and numeric characters.

1.29. Task Order Number

Field Type: Text
Field Size: 6 characters
Example: 11
Definition: Caltrans task order number under which sample was collected.
Notes: This data field can contain any combination of text and numeric characters.

1.30. Sample Notes

Field Type: Text
Field Size: 255 characters
Example: Sample End Time missing due to malfunctioning automated sampler.
Definition: This data field contains any notes or remarks about the sample or various data fields used to describe the sample.
Notes: Data reporter should provide a note for any data field left blank (with the exception of Overall Qualifier). It is not appropriate to provide a note in a particular cell of a data field other than Sample Notes. Considering the example above, it is not appropriate to place the note, "Sample End Time missing due to malfunctioning automated sampler", in the Sample End Time data field. The note must be entered into the Sample Notes data field.

2. WATER QUALITY SAMPLING EVENT DESCRIPTIONS

2.1. Mobilization ID

Field Type: Text
Field Size: 20 characters
Example: 2003-01
Definition: A unique, site-specific identification code assigned to the mobilization effort for a particular sampling event that occurred at a particular monitoring site.
Notes: Mobilization ID follows the format YYYY-Some combination of text and/or numbers ("Year monitoring season begins-Unique string of text and/or numbers that signify to the data provider a specific storm event that occurred at a particular monitoring site"). Even if a site isn't monitored until the latter half of the monitoring season (e.g., Site X is monitored during Feb. – Apr. 2004 – the latter half of the 2003-2004 monitoring season), its Mobilization IDs include the year in which the general Caltrans monitoring season began (i.e., Mobilization IDs for samples collected at Site X would al begin with "2003").

2.2. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-21
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located. Monitoring sites in a given Caltrans District numbered between 1 and 0 must be reported with a 0 (zero) in their Monitoring Site IDs (e.g., 7-09, as opposed to 7-9).

2.3. Event Type

Field Type: Text
Field Size: 10 characters
Example: Non-storm
Definition: Describes if sampling event is associated with a storm event or a non-storm event.
Notes: Standardized Entry. Select value from standard list or contact database manager. This data field quickly describes whether an event record includes precipitation and flow data (i.e., event is a storm event) or does not necessarily include such precipitation and flow data (i.e., event is a non-storm event, such as a dry weather or groundwater sampling event; note: flow data could be provided for a dry weather event). Storm event records that are missing various precipitation and flow data due to malfunctioning equipment must be described with Event Type equal to "Storm" and include remarks in their Event Notes data field as to why certain data are missing.

<u>Standard List</u>

- Storm
- Non-storm

2.4. Rain Start Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which precipitation event begins. See "Definition of a Precipitation Event" in the General Instructions section of this document.
Notes: Formatted as mm/dd/yyyy.

2.5. Rain Start Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which precipitation event begins. See "Definition of a Precipitation Event" in the General Instructions section of this document.
Notes: Formatted for 24-hour clock (hh:mm).

2.6. Rain End Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which precipitation event ends. See "Definition of a Precipitation Event" in the General Instructions section of this document.
Notes: Formatted as mm/dd/yyyy.

2.7. Rain End Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which precipitation event ends. See "Definition of a Precipitation Event" in the General Instructions section of this document.
Notes: Formatted for 24-hour clock (hh:mm).

2.8. Event Rain (mm)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 15.99
Definition: Total rain at site for an event in millimeters (mm).
Notes: The Site Descriptions data field named Rain Record Source identifies the source of the Event Rain data for a particular monitoring site. See "Definition of a Precipitation Event" in the General Instructions section of this document.

2.9. Max Intensity (mm/hr)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 12.18
Definition: Peak 5-minute intensity of a storm event in millimeters/hour (mm/hr).
Notes: Maximum Intensity is calculated as twelve times (12 x) the maximum rainfall recorded in any 5-minute period.

2.10. Antecedent Dry (days)

Field Type: Numeric
Field Size: Provide number only to one (1) decimal place.
Example: 12.0
Definition: Days since the end of the most recent prior Caltrans-defined precipitation event (whether monitored or not). If datum exists, irrespective of whether the prior event was monitored, data reporter should include Antecedent Dry datum as part of the Event Record for the current event.
Notes: See "Definition of a Precipitation Event" in the General Instructions section of this document. With reference to the first precipitation event monitored at a particular monitoring site, it might be necessary to look back in time before the start of the current monitoring season (typically Oct. 1st) to identify the last precipitation event that occurred at said site. If data exist for a precipitation event that occurred during June through September (i.e., occurred between the current and previous monitoring season), then these data should be used when calculating the Antecedent Dry value for the first precipitation event monitored during the current monitoring season.

2.11. Antecedent Event Rain (mm)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 24.37
Definition: Total rain at site for the most recent antecedent Caltrans-defined precipitation event in millimeters (mm). The antecedent precipitation event used for this data field should be the <u>same</u> antecedent precipitation event referenced in the Antecedent Dry data field. The quantification of Antecedent Event Rain does <u>not</u> include "inter-event" precipitation.
Notes: Using the examples provided above for Antecedent Dry and Antecedent Event Rain, the antecedent or prior precipitation event for Site X occurred 12.0 days ago, and delivered 24.37 mm of rainfall. The antecedent precipitation event must meet Caltrans' criteria for a precipitation event. See "Definition of a Precipitation Event" in the General Instructions section of this document.
With reference to the first precipitation event monitored at a particular monitoring site, it might be necessary to look back in time before the start of the current monitoring season (typically Oct. 1st) to identify the last precipitation event that occurred at said site. If data exist for a precipitation event that occurred during June through September (i.e., occurred between the current and previous monitoring season), then these data should be used when calculating the Antecedent Event Rain value for the first precipitation event monitored during the current monitoring season.

2.12. Peak Capture

Field Type: Text
Field Size: 1 character
Example: Y
Definition: Indication of whether peak flow was captured during sampling event.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Y - Yes, peak flow was captured.
- N - No, peak flow was not captured.

2.13. Runoff Start Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which first runoff begins.
Notes: Formatted as mm/dd/yyyy.

2.14. Runoff Start Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which first runoff begins.
Notes: Formatted for 24-hour clock (hh:mm).

2.15. Runoff End Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which last runoff ceases.
Notes: Formatted as mm/dd/yyyy.

2.16. Runoff End Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which last runoff ceases.
Notes: Formatted for 24-hour clock (hh:mm)

2.17. Total Flow Volume (L)

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 38686
Definition: Total measured flow volume in liters (L) at a monitoring site for an event.

2.18. Peak Flow (L/s)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 3.40
Definition: Estimated peak flow of runoff in liters per second (L/s) at a monitoring site for an event.

2.19. Estimated Percent Capture

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 99
Definition: Estimated percentage of total event flow volume during which monitoring was performed (i.e., while the sampler was activated and flow-proportioned sample collection was successfully occurring). Report datum only if estimate is based on actual runoff and sample collection data measured by an instrument located at the monitoring site in question.
Notes: Periods of sampler malfunction or failure to collect sample must be excluded from the "captured flow".

2.20. Cumulative Precipitation (mm)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 100.76
Definition: Estimated cumulative precipitation in millimeters (mm) at monitoring site since the beginning of the water year (October 1), up to the Rain Start Date/Time for the monitored event. All precipitation that has fallen to date at a site, including "inter-event" precipitation, should be included in the Cumulative Precipitation value reported for that site for a particular event.

2.21. Sample Collector

Field Type: Text
Field Size: 25 characters
Example: Roy Estrada
Definition: Name of the individual who collected the sample.

2.22. Organization

Field Type: Text
Field Size: 30 characters
Example: Acme Environmental
Definition: Organization to which the sample collector is associated.

2.23. Event Notes

Field Type:	Text
Field Size:	255 characters
Example:	Runoff End Time missing due to malfunctioning flow meter.
Definition:	This data field contains any notes or remarks about the sampling event or various data fields used to describe the sampling event.
Notes:	Data reporter should provide a note for any data field left blank. It is not appropriate to provide a note in a particular cell of a data field other than Event Notes. Considering the example above, it is not appropriate to place the note, "Runoff End Time missing due to malfunctioning flow meter", in the Runoff End Time data field. The note must be entered into the Event Notes data field.

3. WATER QUALITY SITE DESCRIPTIONS

3.1. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-21
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located. Monitoring sites in a given Caltrans District numbered between 1 and 9 must be reported with a 0 (zero) in their Monitoring Site IDs (e.g., 7-09, as opposed to 7-9).

3.2. Monitoring Year

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 2003
Definition: Identifies the monitoring season a site is monitored by populating the data field with the year the current monitoring season begins.
Notes: In regard to the 2003-2004 monitoring season, the Monitoring Year value for each site monitored would be "2003" – the year the current monitoring season began. The term Monitoring Year refers to only a single calendar year, while the term Monitoring Season necessarily refers to two calendar years, such as 2003-2004.

3.3. Site Name

Field Type: Text
Field Size: 100 characters
Example: DICE Site 12/23
Definition: Name of monitoring site.
Notes: Site Name is meant to be a shorthand designation for the monitoring site, and the "common name" by which the sampling crew and data reporter refer to the site.

3.4. Site Description

Field Type: Text
Field Size: 255 characters
Example: East of Ocean View Avenue Onramp to EB 210 Fwy; a low-density residential site within foothills.
Definition: Describes monitoring site in some detail, including observations related to site's location and physical characteristics.
Notes: In addition to the above definition, this field can be used to describe changes observed at the site since the prior monitoring season.

3.5. Caltrans District

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 7
Definition: Caltrans district in which monitoring site is located.

3.6. Hydrologic Sub-Area

Field Type: Numeric
Field Size: Provide 5-digit number in the format XXX.XX
Example: 405.32
Definition: State Water Resources Control Board (SWRCB) Hydrologic Unit Sub-Area in which monitoring site is located.
Notes: SWRCB Hydrologic codes are 6-byte strings composed of numbers and a decimal point. The meaning associated with each byte position is shown below.

Byte(s)	Meaning
1	Hydrologic Region
2,3	Hydrologic Unit
4	Decimal point
5	Hydrologic Area
6	Hydrologic Sub-Area

Hydrologic sub-areas are typically identified in Basin Plans. They may also be found at the Water Quality Standards Inventory Database web site: http://endeavor.des.ucdavis.edu/wqsid/region.asp

3.7. County

Field Type: Text
Field Size: 25 characters
Example: Los Angeles
Definition: County in which monitoring site is located.
Notes: It is not necessary to include the word "County" along with the actual name of the county in which the monitoring site is located.

3.8. RWQCB

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 4
Definition: Regional Water Quality Control Board (RWQCB) region in which monitoring site is located.

3.9. Runoff Characterization

Field Type: Text
Field Size: 25 characters
Example: Hwy
Definition: Type of runoff characterized by samples collected from monitoring site.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Hwy - Highway or Freeway
- Maintenance - Maintenance facility
- Parking - Parking lot (e.g., Park & Ride facility)
- Rest Area - Rest area
- Free-Flowing - Free-flowing traffic area
- Congested - Congested traffic area
- Construction - Construction
- BMP - Site designed for storm water treatment
- Border Check-point - Border Check-point
- Bridge - Bridge
- CVIF - Commercial Vehicle Inspection Facility
- Erosion - Erosion study
- Receiving - Receiving water (described further in "Receiving Water Type)
- Toll Plaza - Toll Plaza
- Watershed - Urban or rural watershed (described further in "Land Use")

3.10. Surface Type

Field Type: Text
Field Size: 25 characters
Example: Asphalt
Definition: Describes the predominant surface type associated with a Caltrans facility.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Landscape - Landscaping
- Asphalt - Asphalt only
- Concrete - Concrete only
- Asphalt/Concrete - Mixture of asphalt and concrete
- Right-of-Way - Right-of-Way (includes landscape, asphalt and/or concrete)
- Construction Site - Graded construction site

3.11. Land Use

Field Type: Text
Field Size: 4 characters
Example: R
Definition: Predominant land use of the tributary catchment area. This field describes the predominant land use of the area from which sampled runoff originates.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- R - Residential
- C - Commercial
- I - Industrial
- A - Agricultural
- F - Forest
- O - Open
- T - Transportation Facility (e.g., bridge, county road, highway, etc.)
- M - Mixed (no predominant land use can be discerned)

3.12. Catchment Area (ha)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 2.91
Definition: Total surface area in hectares (ha) draining to the point of collection of the storm water runoff sample.

3.13. Impervious Fraction

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 0.67
Definition: Estimated fraction of the catchment area that is effectively impervious. Impervious Fraction values will range from 0 – 1.

3.14. BMP Type

Field Type: Text
Field Size: 50 characters
Example: EDB
Definition: Describes the type of BMP represented by the monitoring site. This data field to be populated only for monitoring sites designed to treat storm water runoff. All non-BMP sites should have this data field value reported as "N/A".
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Retention - Retention Pond
- Swale - Biofiltration Swale
- EDB - Extended Detention Basin
- Wet Pond - Wet Detention Pond
- Dry Pond - Extended Dry Detention Pond
- Compost - Compost Media Filter
- Zeolite - Zeolite Media Filter
- SF - Sand Media Filter
- IB - Infiltration Basin
- IT - Infiltration Trench
- TCB - Trapping Catch Basin
- Insert - Drain Inlet Insert
- Strip - Biofiltration Strip
- Strip-Trench - Filtration Strip and Infiltration Trench Treatment Train
- Silt Fence - Silt Fence
- Gravel Bags - Gravels Bags (commonly used at construction sites)
- Sand Bags - Sand Bags (commonly used at construction sites)
- Straw Bales - Straw Bales (commonly used at construction sites)
- OWS - Oil/Water or Debris Separator
- MCTT - Mult-chambered Treatment Train
- CDS - Continuous Deflector Separator
- DBST - Double-Barrel Sand Trap
- DISump - Drain Inlet with Sump
- Wetland - Natural or man-made wetland
- DIC - Drain Inlet Cleaning
- Pickup - Gross Solids Pickup (gross solids studies)
- Sweep - Street Sweeping (gross solids studies)
- ModifyIn - Modified Inlet (gross solids studies)
- Grate - Bicycle Grate/LID (gross solids studies)
- ModGrate - Modified Bicycle Grate (gross solids studies)
- Baffle Box - Baffle Box (gross solids studies)
- FSVS - Forward Sloping V Screen (gross solids studies)
- RSVS - Reverse Sloping V Screen (gross solids studies)
- IBS - Inclined Bar Screen (gross solids studies)
- LRD - Linear Radial Device (gross solids studies)

Alternate Value: - N/A (see Definition above).

3.15. Point of Collection

Field Type: Text
Field Size: 25 characters
Example: Discharge
Definition: Describes the point of sample collection at the monitoring site.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Discharge - Outfall to receiving water or outlet to conveyance system
- Inlet - Inlet to BMP
- Outlet - Outlet to BMP
- Within - Sample collection point somewhere within BMP
- Bypass - Bypass structure associated with BMP
- Overflow - Overflow structure associated with BMP
- Up GSRD - Upstream of Gross Solids Removal Device
- Down GSRD - Downstream of Gross Solids Removal Device
- Overland - Overland flow
- Receiving - Location(s) in receiving water (stream, lake, etc.)

3.16. Control Site

Field Type: Text
Field Size: 25 characters
Example: 7-156
Definition: The Caltrans Monitoring Site ID for the control or BMP "inlet" site associated with the BMP "outlet" or BMP "within" site in question. All non-BMP sites and BMP "inlet" sites should have this data field value reported as "N/A".
Notes: A small number of BMP sites do not possess a control or reference site. These sites should have this data field populated with the value "No Control for BMP".

Alternate Values: - N/A (see Definition above).
- No Control for BMP (see Notes above).

3.17. Cut-Fill

Field Type: Text
Field Size: 15 characters
Example: Cut
Definition: Identifies the roadway or facility as a cut, fill, grade or hybrid type (e.g., Grade/Fill) site.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Cut - Sample collected from a cut area.
- Fill - Sample collected from a fill area.
- Grade - Sample collected from a grade area.
- Cut/Fill - Sample collected from a roadway or facility with both cut and fill areas.
- Grade/Cut - Sample collected from a roadway or facility with both grade and cut areas.
- Grade/Fill - Sample collected from a roadway or facility with both grade and fill areas.

3.18. Roadway Post Mile

Field Type: Text
Field Size: 18 characters
Example: I-210-EB-18.45
Definition: A four-part descriptor that describes the roadway type, roadway number, traffic direction, and post mile of the Caltrans highway facility nearest to the monitoring site. If no such Post Mile exists for a site, the data field value should be reported as "N/A".
Notes: The Roadway Post Mile value is a compilation of the following four pieces of information: **Roadway Type-Roadway Number-Traffic Direction-Post Mile**
Standardized entries exist for roadway type and traffic direction.
Select values from standard lists or contact database manager.

Standard Lists

Roadway Type

- I - Interstate
- SR - State Route
- CR - County Road

Traffic Direction

- EB - Eastbound
- WB - Westbound
- NB - Northbound
- SB - Southbound

Alternate Value: - N/A (see Definition above).

3.19. Latitude

Field Type: Numeric
Field Size: Provide number to five (5) decimal places.
Example: 34.20969
Definition: Latitude of monitoring site in decimal degrees to five (5) decimal places.
Notes: Data should be collected using a differential GPS instrument with sufficient accuracy to report degrees to five decimal places.

3.20. Longitude

Field Type: Numeric
Field Size: Provide number to five (5) decimal places.
Example: 118.22469
Definition: Longitude of monitoring site in decimal degrees to five (5) decimal places.
Notes: Data should be collected using a differential GPS instrument with sufficient accuracy to report degrees to five decimal places

3.21. Datum

Field Type: Text
Field Size: 20 characters
Example: NAD 83
Definition: Datum by which latitude and longitude reported.

3.22. Rain Record Source

Field Type: Text
Field Size: 50 characters
Example: NOAA
Definition: Source of precipitation record used in precipitation estimates.
Notes: Report "Onsite" if rain gauge is located at the monitoring site, or report the name/location of the nearest rain gauge. Actual precipitation event record (i.e., rainfall data from rain gauge) should be included in a Time Series worksheet for the event (see Time Series data field description in this section).

3.23. Receiving Water Type

Field Type: Text
Field Size: 20 characters
Example: Intermittent
Definition: Type of receiving water sampled or into which storm water runoff is discharged.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Intermittent - Intermittent or seasonal stream or channel
- Wetlands - Seasonal or perennial wetlands
- River - Perennial freshwater river
- Stream - Perennial freshwater stream
- Lake - Freshwater lake or impoundment
- Pond - Freshwater pond
- Bay - Salt or brackish water bay
- Estuary - Salt or brackish water estuary
- Groundwater - Runoff percolates into soil profile surrounding monitoring site and ostensibly enters groundwater
- Ocean

3.24. AADT

Field Type: Numeric
Field Size: N/A
Example: 120000
Definition: Average annual daily traffic (AADT) flow at or near monitoring site.
Notes: If site is a maintenance yard, parking lot, or rest area, report the estimated number of vehicles entering and leaving the facility each day. Note that Southbound or Westbound traffic counts are usually represented by the "Back AADT" number provided in the AADT database, whereas the Northbound or Eastbound traffic counts are usually represented by the "Ahead AADT" number. For more information, please visit the following Caltrans web page:

http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/2002all.htm

3.25. AADT Source

Field Type: Text
Field Size: 100 characters
Example: http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/2003all.htm
Definition: Source or reference for reported AADT value.
Notes: A searchable AADT database is available at the Caltrans Traffic and Vehicle Data Systems Unit web page:

http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/

Note that Southbound or Westbound traffic counts are usually represented by the "Back AADT" number provided in the AADT database, whereas the Northbound or Eastbound traffic counts are usually represented by the "Ahead AADT" number.

3.26. Adjacent Lanes

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 2
Definition: The number of traffic lanes adjacent to the monitoring site that contribute storm water runoff that is sampled at the monitoring site's point of collection.
Notes: In many cases, the numeric value populating this data field will be a summation of the number of lanes of traffic moving in one direction only next to the monitoring site.

This data field need only be populated for HIGHWAY monitoring sites (i.e., monitoring sites having Runoff Characterization = "Hwy").

3.27. Total Lanes

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 4
Definition: The total number of traffic lanes (traffic moving in both directions) neighboring the monitoring site.
Notes: This data field should specify all lanes of traffic near the monitoring site that may impact storm water runoff through the deposition of airborne pollutants.

This data field need only be populated for HIGHWAY monitoring sites (i.e., monitoring sites having Runoff Characterization = "Hwy").

3.28. EROW Sampling

Field Type: Text
Field Size: 3 characters
Example: Yes
Definition: Describes whether or not sampled runoff was collected at the edge of Caltrans right-of-way.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Yes - Runoff collected at edge of Caltrans right-of-way. Runoff immediately leaves Caltrans right-of-way beyond the point at which it was sampled.
- No - Runoff not collected at edge of Caltrans right-of-way. Runoff continues to have contact with Caltrans right-of-way beyond the point at which it was sampled.

3.29. Runoff Commingle

Field Type: Text
Field Size: 3 characters
Example: Yes
Definition: Describes whether or not sampled runoff commingles with non-Caltrans discharge(s) prior to its collection.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Yes - Sampled runoff is comprised of runoff originating from a Caltrans facility, ***as well as*** runoff originating from another source.
- No - Sampled runoff is comprised entirely of runoff originating from a Caltrans facility.

3.30. Paved Surface Contact

Field Type: Text
Field Size: 3 characters
Example: Yes
Definition: Describes whether or not sampled runoff contacts only paved surfaces (asphalt and/or concrete) prior to its collection.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Yes - Sampled runoff contacts only paved surfaces prior to its collection.
- No - Sampled runoff contacts both paved and unpaved surfaces prior to its collection.

3.31. Runoff Treatment

Field Type: Text
Field Size: 10 characters
Example: Vegetation
Definition: Describes what kind of treatment, if any, sampled runoff is exposed to prior to its collection.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Bare soil - Sampled runoff comes into contact with bare soil prior to its collection.
- BMP - Sampled runoff is treated by a BMP device prior to its collection.
- Soil/BMP - Sampled runoff comes into contact with bare soil and is treated by a BMP device prior to its collection.
- Vegetation - Sampled runoff comes into contact with vegetation prior to its collection.
- Veg/BMP - Sampled runoff comes into contact with vegetation and is treated by a BMP device prior to its collection.
- Mixed - Sampled runoff comes into contact with both bare soil and vegetation prior to its collection.
- Mixed/BMP - Sampled runoff comes into contact with both bare soil and vegetation, and is treated by a BMP device prior to its collection.
- None - Sampled runoff contacts only paved surfaces prior to its collection.

3.32. Time Series

Field Type: Text
Field Size: 75 characters
Example: Site 7-21 Time Series_2003-2004.xls
Definition: The name of the Excel worksheet in which time series data (flow, precipitation, etc.) collected at a monitoring site is submitted.
Notes: Times series data collected during storm events at a monitoring site can be submitted as multiple worksheets (one worksheet for each storm event) in a single workbook that represents all times series data collected at that site during an entire monitoring season. The Excel workbook file should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2003-2004 or 03-04) to which it corresponds.

3.33. Map

Field Type: Text
Field Size: 50 characters
Example: Site 7-21 Map_2003-2004.pdf
Definition: The name of the electronic document containing a map that shows the location of the monitoring site.
Notes: The actual electronic document containing a map of the monitoring site should be submitted along with the rest of the data collected for the site, including water quality data, time series data, and one or more photographs. The map should contain the clearly marked location of the monitoring site, latitude and longitude markers, and the watershed contributing flows to the site. The electronic map document should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2003-2004 or 03-04) to which it corresponds.

3.34. Photograph

Field Type: Text
Field Size: 100 characters
Example: Site 7-21 Photo_2003-2004.jpeg
Definition: The name of the electronic document containing photograph(s) of the monitoring site.
Notes: The actual electronic document containing photograph(s) of the monitoring site should be submitted along with the rest of the data collected for the site, including water quality data, time series data, and a map. The electronic photograph document should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2003-2004 or 03-04) to which it corresponds.

3.35. Site Notes

Field Type: Text
Field Size: 255 characters
Example: No AADT value provided for this site. Site is located along a county road for which no AADT data are available.
Definition: This data field contains any notes or remarks about the monitoring site or various data fields used to describe the monitoring site.
Notes: Data reporter should provide a note for any data field left blank. It is not appropriate to provide a note in a particular cell of a data field other than Site Notes. Considering the example above, it is not appropriate to place the note, "No AADT value provided for this site. Site is located along a county road for which no AADT data are available", in the AADT data field. The note must be entered into the Site Notes data field.

4. STANDARD CONSTITUENT NAMES

4.1. Metals (ug/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Al	7429-90-5	Fe	7439-89-6
Sb	7440-36-0	Pb	7439-92-1
As	7440-38-2	Hg (ng/L)	7439-97-6
Be	7440-41-7	Mo	7439-98-7
Cd	7440-43-9	Ni	7440-02-0
Cr	7440-47-3	Se	7782-49-2
Cr (III)	16065-83-1	Ag	7440-22-4
Cr (VI)	18540-29-9	Tl	7440-28-0
Co	7440-48-4	V	7440-62-2
Cu	7440-50-8	Zn	7440-66-6

4.2. Nutrients (mg/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
NH3-N	7664-41-7	Ortho-P	CT-ORTHOP
NO2-N	14797-65-0	P	7723-14-0
NO3-N	14797-55-8	TKN	CT-TKN
Organic Nitrogen	CT-ORGN	Total N	CT-TN

4.3. Conventionals (mg/L, typically – unless noted)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Alkalinity as CaCO3	CT-ALKCACO3	Settleable Solids	CT-SETSOL
BOD	CT-BOD	SSC	CT-SSC
COD	CT-COD	Temperature (°C)	CT-TEMP
DO	CT-DO	TDS	CT-TDS
DOC	CT-DOC	TOC	CT-TOC
EC (µmhos/cm)	CT-EC	TSS	CT-TSS
Hardness as CaCO3	CT-HARD	Turbidity (NTU)	CT-TURB
pH (pH units)	CT-PH	Turbidity, filtered (NTU)	CT-TURBFLT
Salinity	CT-Salinity	TVSS	CT-TVSS

4.4. Major Ions (mg/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Ca	7440-70-2	K	7440-09-7
Cl	16887-00-6	Mg	7439-95-4
CO3	CT-CO3	Na	7440-23-5
HCO3	CT-HCO3	SO4	14808-79-8

4.5. Minerals (mg/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Asbestos	1332-21-4	Fluoride	CT-FLUORIDE
B	7440-42-8	Mn	7439-96-5
Ba	7440-39-3	Silica	7631-86-9
Chlorine Residual	CT-CLRES		

4.6. Microbiological (various units)

Constituent	CAS or Caltrans ID#	Constituent	CAS or Caltrans ID #
Bacteria (MPN/100 mL or cfu/100 mL)		**Protozoa**	
E. Coli 0157:H7	CT-ECOLI157	Cryptosporidium parvum (oocysts/100L)	CT-CRYPTO
Enterotoxic E. Coli	CT-ECOLIENTOX	Giardia lamblia (cysts/100L)	CT-GIARDIA
Fecal Coliform	CT-FCOLI		
Fecal Enterococci	CT-FENTERO		
Fecal Streptococci	CT-FSTREP		
Salmonella sp.	CT-SALMONEL	**Viruses (TCID[50]/100 mL)**	
Shigella sp.	CT-SHIGELLA	Adenovirus	CT-ADENOVI
Staphylococcus sp.	CT-STAPH	Enterovirus	CT-ENTEROVI
Total Coliform	LDC-0381	Hepatitis A	CT-HEPATITISA
Pseudomonas Aeruginosa	CT-AERUG	Rotavirus	CT-ROTAVI

4.7. VOCs (EPA 8260, 601, 602, 603, 1624; ug/L, typically)

Constituent	CAS or Caltrans ID #
1,1,1,2-Tetrachloroethane	630-20-6
1,1,1-Trichloroethane	71-55-6
1,1,2,2-Tetrachloroethane	79-34-5
1,1,2-Trichloroethane	79-00-5
1,1-Dichloroethane	75-34-3
1,1-Dichloroethylene	75-35-4
1,1-Dichloropropene	563-58-6
1,2,3-Trichlorobenzene	87-61-6
1,2,3-Trichloropropane	96-18-4
1,2,4-Trimethylbenzene	95-63-6
1,2-Dibromo-3-chloropropane	96-12-8
1,2-Dibromoethane	106-93-4
1,2-Dichlorobenzene	95-50-1
1,2-Dichloroethane	107-06-2
1,2-Dichloropropane	78-87-5
1,3,5-Trimethylbenzene	108-67-8
1,3-Dichlorobenzene	541-73-1
1,3-Dichloropropane	142-28-9
1,3-Dichloropropene	542-75-6
1,4-Dichlorobenzene	106-46-7
2,2-Dichloropropane	594-20-7
2-Butanone	78-93-3
2-Chloroethylvinyl ether	110-75-8
2-Chlorotoluene	95-49-8
2-Hexanone	591-78-6
4-Bromofluorobenzene	460-00-4
4-Chlorotoluene	106-43-4
4-Methyl-2-pentanone (MIBK)	108-10-1
Acetone	67-64-1
Acrolein	107-02-8
Acrylonitrile	107-13-1
Benzene	71-43-2
Benzyl chloride	100-44-7
Bromobenzene	108-86-1
Bromochloromethane	74-97-5
Bromoform	75-25-2
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chlorodibromomethane	124-48-1
Chloroethane	75-00-3

Constituent	CAS or Caltrans ID #
Chloroform	67-66-3
cis-1,2-Dichloroethene	156-59-2
cis-1,3-Dichloropropene	10061-01-5
cis-1,4-Dichloro-2-butene	1476-11-5
Dibromofluoromethane	1868-53-7
Dibromomethane	74-95-3
Dichlorobromomethane	75-27-4
Dichlorodifluoromethane	75-71-8
Ethanol	64-17-5
Ethylbenzene	100-41-4
Iodomethane	74-88-4
Isopropylbenzene	98-82-8
Methanol	67-56-1
Methyl bromide	74-83-9
Methyl chloride	74-87-3
Methylene chloride	75-09-2
Methyl-t-butyl ether (MTBE)	1634-04-4
m-Xylene	108-38-3
m,p-Xylenes	CT-XYLENES-M-P
n-Butylbenzene	104-51-8
n-Propylbenzene	103-65-1
o-Xylene	95-47-6
Pentachloroethane	76-01-7
p-Isopropyltoluene	99-87-6
p-Xylene	106-42-3
Pyridine	110-86-1
sec-Butylbenzene	135-98-8
Styrene	100-42-5
tert-Butylbenzene	98-06-6
Tetrachloroethylene (PCE)	127-18-4
Tetrahydrofuran	109-99-9
Toluene	108-88-3
trans-1,2-Dichloroethene	156-60-5
trans-1,3-Dichloropropene	10061-02-6
trans-1,4-Dichloro-2-butene	110-57-6
Trichloroethylene (TCE)	79-01-6
Trichlorofluoromethane	75-69-4
Vinyl acetate	108-05-4
Vinyl chloride	75-01-4
Xylenes (total)	1330-20-7

4.8. SVOCs (EPA 8250/8270, 625; ug/L, typically)

Constituent	CAS or Caltrans ID #
1,2,4-Trichlorobenzene	120-82-1
1,2-Diphenylhydrazine	122-66-7
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2
2,4-Dichlorophenol	120-83-2
2,4-Dimethylphenol	105-67-9
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2,6-Dichlorophenol	87-65-0
2,6-Dinitrotoluene	606-20-2
2-Chloronaphthalene	91-58-7
2-Chlorophenol	95-57-8
2-Methyl-4,6-dinitrophenol	534-52-1
2-Methylnaphthalene	91-57-6
2-Methylphenol (o-Cresol)	95-48-7
2-Nitroaniline	88-74-4
2-Nitrophenol	88-75-5
3,3′-Dichlorobenzidine	91-94-1
3-Methyl-4-chlorophenol	59-50-7
3-Methylphenol (m-Cresol)	108-39-4
3-Nitroaniline	99-09-2
4-Bromophenyl phenyl ether	101-55-3
4-Chloroaniline	106-47-8
4-Chlorophenyl phenyl ether	7005-72-3
4-Methylphenol (p-Cresol)	106-44-5
4-Nitroaniline	100-01-6
4-Nitrophenol	100-02-7
Acenaphthene	83-32-9
Acenaphthylene	208-96-8
Aniline	62-53-3
Anthracene	120-12-7
Benzidine	92-87-5
Benzo(a)anthracene	56-55-3
Benzo(a)pyrene	50-32-8
Benzo(b)fluoranthene	205-99-2
Benzo(ghi)perylene	191-24-2

Constituent	CAS or Caltrans ID #
Benzo(k)fluoranthene	207-08-9
Benzoic acid	65-85-0
Benzyl alcohol	100-51-6
Bis(2-chloroethoxy)methane	111-91-1
Bis(2-chloroethyl)ether	111-44-4
Bis(2-chloroisopropyl)ether	39638-32-9
Bis(2-ethylhexyl)phthalate	117-81-7
Butylbenzyl phthalate	85-68-7
Carbazole	86-74-8
Chrysene	218-01-9
Dibenzo(a,h)anthracene	53-70-3
Dibenzofuran	132-64-9
Diethyl phthalate	84-66-2
Dimethyl phthalate	131-11-3
Di-n-Butyl phthalate	84-74-2
Di-n-Octyl phthalate	117-84-0
Endrin ketone	53494-70-5
Fluoranthene	206-44-0
Fluorene	86-73-7
Hexachlorobenzene	118-74-1
Hexachlorobutadiene	87-68-3
Hexachlorocyclopentadiene	77-47-4
Hexachloroethane	67-72-1
Indeno(1,2,3-cd)pyrene	193-39-5
Isophorone	78-59-1
Naphthalene	91-20-3
Nitrobenzene	98-95-3
N-Nitrosodimethylamine	62-75-9
N-Nitrosodi-N-propylamine	621-64-7
N-Nitrosodiphenylamine	86-30-6
PAHs	CT-PAH
Pentachlorophenol	87-86-5
Phenanthrene	85-01-8
Phenol	108-95-2
Phenolics	CT-PHENOLICS
Pyrene	129-00-0

4.9. OC Pesticides (EPA 8080/8081; ug/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
4,4′-DDD	72-54-8	Dieldrin	60-57-1
4,4′-DDE	72-55-9	Endosulfan sulfate	1031-07-8
4,4′-DDT	50-29-3	Endrin	72-20-8
Aldrin	309-00-2	Endrin aldehyde	7421-93-4
alpha-BHC	319-84-6	gamma-BHC	58-89-9
alpha-Chlordane	5103-71-9	gamma-Chlordane	5103-74-2
alpha-Endosulfan	959-98-8	Heptachlor	76-44-8
beta-BHC	319-85-7	Heptachlor expoxide	1024-57-3
beta-Endosulfan	33213-65-9	Methoxychlor	72-43-5
Chlordane	57-74-9	Mirex	2385-85-5
delta-BHC	319-86-8	Toxaphene	8001-35-2

4.10. OP Pesticides (EPA 8140/8141; ug/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Azinphos methyl	86-50-0	Merphos	150-50-5
Bolstar (Sulprofos)	35400-43-2	Methidathion	950-37-8
Chlorpyrifos	2921-88-2	Methyl trithion	953-17-3
Coumaphos	56-72-4	Mevinphos	7786-34-7
Def	78-48-8	Naled	300-76-5
Demeton-O	298-03-3	Parathion, ethyl	56-38-2
Demeton-S	126-75-0	Parathion, methyl	298-00-0
Demeton-O and S	CT-DEMETON-O-S	Phorate	298-02-5
Diazinon	333-41-5	Phosalone	2310-17-0
Dichlorvos	62-73-7	Phosmet	732-11-6
Dimethoate	60-51-5	Prometon	1610-18-0
Diphenamid	957-51-7	Prowl	40487-42-1
Disulfoton	298-04-4	Ronnel	299-84-3
Ethion	563-12-2	Simazine	122-34-9
Ethoprop	13194-48-4	Stirophos (Tetrachlorvinphos)	22248-79-9
Fensulfothion	115-90-2	Tokuthion (Prothiofos)	34643-46-4
Fenthion	55-38-9	Trichloronate	327-98-0
Malathion	121-75-5	Trifluralin	1582-09-8

4.11. Other Pesticides (EPA 8150; ug/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
2,4,5-T	93-76-5	Dicamba	1918-00-9
2,4,5-TP (Silvex)	93-72-1	Dichlorprop	120-36-5
2,4-D	94-75-7	Dinoseb (DNBP)	88-85-7
2,4-DB	94-82-6	MCPA	94-74-6
Dalapon	75-99-0	MCPP	93-65-2

4.12. Miscellaneous Pesticides (ug/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Alachlor	15972-60-8	Metolachlor	51218-45-2
Atrazine	1912-24-9	Molinate	2212-67-1
Bromacil	314-40-9	Oryzalin	19044-88-3
Cacodylic acid	75-60-5	Oxadiazon	19666-30-9
Chlorsulfuron	64902-72-3	Oxamyl	23135-22-0
Cyanazine	21725-46-2	Oxyfluorfen	42874-03-3
Diquat	85-00-7	Paraquat	4685-14-7
Diuron	330-54-1	Prometryn	7287-19-6
Fluazifop-p-butyl	69806-50-4	Sulfometuron-methyl	74222-97-2
Glyphosate	1071-83-6	Thiobencarb	28249-77-6
Isoxaben	82558-50-7	Triclopyr	55335-06-3
Mefluidide	53780-34-0		

4.13. Polychlorinated Biphenyls – PCBs (ug/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Arochlor 1016	12674-11-2	Arochlor 1248	12672-29-6
Arochlor 1221	11104-28-2	Arochlor 1254	11097-61-1
Arochlor 1232	11141-16-5	Arochlor 1260	11096-82-5
Arochlor 1242	53469-21-9	PCBs (total)	CT-TPCB

4.14. Hydrocarbons (mg/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Oil & Grease	CT-OILGREASE	TPH (Kerosene)	CT-KEROSENE
TEPH	CT-TEPH	TPH (Motor Oil)	CT-MOIL
TPH (Diesel)	68334-30-5	TPH (Stoddard Solvent)	CT-STODSOL
TPH (Gasoline)	8006-61-9	TRPH	CT-TRPH
TPH (Heavy Oil)	CT-HOIL	TVPH	CT-TVPH
TPH (Jet Fuel)	CT-JETFUEL		

4.15. Miscellaneous Constituents (ug/L, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID
2,3,7,8-Tetrachloro-dibenzo-p-dioxin	1746-01-6	Coprostanol	CT-COPROS
Chlorophyll-a	CT-CHLOROPHYLL	Epicoprostanol	CT-EPICOPROS
Cyanide (mg/L)	57-12-5	Fecal Sterol	CT-FSTEROL

5. MEASURING UNITS CONVERSION TABLES

5.1. Length Conversions

Metric	Converting to >	Imperial
1 millimeter (mm)		0.0394 in
1 centimeter (cm)	10 mm	0.3937 in
1 meter (m)	100 cm	3.2808 ft
1 meter (m)	100 cm	1.0936 yd
1 kilometer (km)	1,000 m	0.6214 mile

Imperial	Converting to >	Metric
1 inch (in)		25.40 mm
1 inch (in)		2.54 cm
1 foot (ft)	12 in	0.3048 m
1 yard (yd)	3 ft	0.9144 m
1 mile	1,760 yd	1.6093 km

5.2. Area Conversions

Metric	Converting to >	Imperial
1 square cm (cm^2)	100 mm^2	0.1550 in^2
1 square m (m^2)	10,000 cm^2	1.1960 yd^2
1 hectare (ha)	10,000 m^2	2.4711 acres
1 square km (km^2)	100 ha	0.3861 $mile^2$

Imperial	Converting to >	Metric
1 square inch (in^2)		6.4519 cm^2
1 square foot (ft^2)	144 in^2	0.0929 m^2
1 square yard (yd^2)	9 ft^2	0.8361 m^2
1 acre	4840 yd^2	4046.9 m^2
1 acre	4840 yd^2	0.4047 ha
1 square mile ($mile^2$)	640 acres	2.59 km^2

5.3. Volume/Capacity Conversions

Metric	Converting to >	Imperial
1 cubic cm (cm^3)		0.0610 in^3
1 cubic decimeter (dm^3)	1,000 cm^3	0.0353 ft^3
1 cubic meter (m^3)	1,000 dm^3	1.3080 yd^3
1 liter (L)	1 dm^3	1.76 pt
1 hectoliter (hL)	100 L	21.997 gal

Imperial	Converting to >	Metric
1 cubic inch (in^3)		16.387 cm^3
1 cubic foot (ft^3)	1,728 in^3	0.0283 m^3
1 fluid ounce (fl oz)		29.5735 mL
1 pint (pt)	16 fl oz	0.4732 L
1 gallon (gal)	8 pt	3.785 L

5.4. Mass Conversions

Metric	Converting to >	Imperial
1 milligram (mg)		0.0154 grain
1 gram (g)	1,000 mg	0.0353 oz
1 kilogram (kg)	1,000 g	2.2046 lb
1 metric ton (t)	1,000 kg	2,204.6 lb

Imperial	Converting to >	Metric
1 ounce (oz)	437.5 grain	28.35 g
1 pound (lb)	16 oz	0.4536 kg
1 short ton (US)	2,000 lb	0.907 t

5.5. Temperature Conversions

Converting Degrees Fahrenheit to Degrees Celsius
Degrees Fahrenheit (°F) – 32 x 5/9 = Degrees Celsius (°C)

Converting Degrees Celsius to Degrees Fahrenheit
Degrees Celsius (°C) x 9/5 + 32 = Degrees Fahrenheit (°F)

SECTION 2.2

Caltrans Data Reporting Protocols: Particle/Sediment

NOVEMBER 2003

Caltrans Monitoring and
Water Quality Research Program

2003-2004 Particle/Sediment Data Reporting Protocols

CTSW-RT-03-096.51.42

Prepared for:
California Department of Transportation
Environmental Program

GENERAL INSTRUCTIONS

Please read and be familiar with these general instructions. Particle/sediment data can only be accurately and expediently incorporated into the Caltrans Master Stormwater Database if these instructions are carefully followed. Adhering to these instructions will facilitate the processing of data and eliminate the need for time-consuming "record-by-record" data validation at year's end.

- **Get Monitoring Site IDs from Caltrans at the beginning of each monitoring season.**

  Caltrans will assign the "Monitoring Site ID" for all monitoring sites. All Caltrans data reporters are required to contact the Caltrans database manager (Mike Trouchon – Larry Walker Associates) at the **beginning** of each sampling season to receive Monitoring Site IDs for each new site they will sample. Note that BMP sites having multiple points of collection (e.g., inlet, within, outlet, bypass, overflow, etc.) will be assigned a unique Monitoring Site ID for each point of collection. Data reporters shall provide the database manager with the name of each site, the type of monitoring to be performed, and the Caltrans district in which each site resides.

- **Enter data appropriately.**

  To facilitate the accurate entry of particle/sediment data into Excel worksheets or Access data tables by Caltrans data reporters, and the subsequent transfer of this data into the Caltrans Master Stormwater Database, each data field described in this data-reporting protocol document possesses the following attributes: Field Name, Field Type, Field Size, Example, Definition, Notes (where applicable), Standard List (where applicable) and Alternate Value (where applicable). These eight data field attributes are defined below.

Field Name	Name of data field as it appears in the Excel worksheet or Access data table used for data reporting.
Field Type	Specifies the type of data, text or numeric that can be stored in a data field. Note: text fields can store both text and numbers.
Field Size	Specifies the number of characters that can be stored in a text field or the number of decimal places required of a number entered into a numeric field.
Example	Provides an example of the data type and possible value that is appropriate for a specific data field.
Definition	Provides a definition of the data type and possible value that is appropriate for a specific data field.
Notes	Provides further information that may be helpful in appropriately and accurately populating a specific data field.
Standard List	Provides a list of standard values appropriate for populating a specific data field.
Alternate Value	Specifies if the use of "N/A" (not applicable) or "None" is an appropriate value for a specific data field.

GENERAL INSTRUCTIONS (CONTINUED)

Additionally, the following rules should be abided by when entering particle/sediment data into either Excel worksheets or Access data tables.

- **Select and enter text values only from the "Standard List"** of values provided for each data field. Standardized values must be entered exactly as specified. Standard lists are included with the description of each data field where appropriate. If a standardized value provided for a particular data field does not accurately describe the data to be entered into that field, please contact the Caltrans database manager to discuss the creation of an additional value for a particular data field.

- **Use "Constituent" names exactly as they appear in the standardized constituent list, and report data in the units specified.** Please refer to Section 4 at the end of these protocols for the list of "Standard Constituent Names".

- **Enter numeric data values according to the definition provided for the particular numeric data field.** Text must not be entered into numeric data fields. Text-based comments regarding a numeric value should be placed in the "Notes" data field.

- **"Mobilization ID" follows the format YYYY-Some combination of text and/or numbers** ("Year monitoring season begins-Unique string of text and/or numbers that signify to the data provider a specific storm event that occurred at a particular monitoring site"). Mobilization IDs for the 2003-2004 Caltrans monitoring season would all begin with "2003".

- **Use the correct system for date entries when using Microsoft Excel.** Dates must be entered using the Excel "1900 Date System" typical for Windows (the "1900 Date System" is the default date system used by Microsoft Excel installed on computers running a Windows operating system). The "Macintosh 1904 Date System" should be switched off in Excel preferences (located in the following nested menus: Tools >> Options >> Calculation). Data providers managing their data exclusively in Microsoft Access need not address this issue.

- **Values contained in data fields that link records from one Excel worksheet or Access table to another, such as Monitoring Site ID and Mobilization ID, must match exactly** for the correct relationship to exist between records once the data is imported into the Caltrans Master Stormwater Database (Version 2.0 built using Microsoft Access 2000). No match can be made between a Monitoring Site ID of "7 –21" (note an extra space between the 7 and the hyphen) found in the Site Descriptions worksheet or data table and a Monitoring Site ID of "7-21" found in the Sample Descriptions worksheet or data table. In general, wherever data field entries are hyphenated, do not include spaces.

- **If any cell in a data field is left blank* (i.e., the data cell is null), a brief note explaining why the data cell was left blank must accompany the particular record.** The brief note shall be placed in the "Notes" data field associated with the particular record containing one or more blank data cells.

  *Exception – The following data field can contain null values without an associated note entered in the "Notes" data field of the relevant worksheet or data table:

Excel Worksheet or Access Table	Data Field
Sample Descriptions	Overall Qualifier

- **The use of "N/A" as a value entered into a text data field is acceptable for some fields** where the data field definition does not apply to the particular data record being entered. For example, the data field "Control Site" (found in the Site Descriptions worksheet) applies only to Caltrans BMP sites for which a control site exists. This data field is "not applicable" to a non-BMP monitoring site with a "Point of Collection" equal to "Discharge". Data fields where the use of "N/A" is acceptable have this data value option specified in the Alternate Value attribute. "N/A" cannot be entered into a numeric data field. ***Additionally, the use of the value "Other" is not acceptable for any data field.***

- **Make sure that all required data records for a particular sampling event exist in the Sample Descriptions, Sampling Event Descriptions and Site Descriptions worksheets or data tables according to the following rules used to maintain referential integrity among all related records:**

  - A Monitoring Site ID value (e.g., 7-21) contained in the Sample Descriptions worksheet or data table must be represented by a single record for the same Monitoring Site ID in the Site Descriptions worksheet or data table.

  - A Monitoring Site ID value (e.g., 7-21) contained in the Site Descriptions worksheet or data table must be represented by at least one record in the Sample Descriptions worksheet or data table.

  - A unique combination of Monitoring Site ID (e.g., 7-21) and Mobilization ID (e.g., 2003-01) contained in the Sample Descriptions worksheet or data table must be represented by a single record for the same unique Monitoring Site ID/Mobilization ID pair in the Sampling Event Descriptions worksheet or data table. Do not forget to create an Event Descriptions record for "non-storm" monitoring events (such as dry weather sampling) even though these events may not include the collection of precipitation and runoff data (Mobilization ID, Site ID, Event Type, Sample Collector, Organization and Event Notes can be populated for these non-storm event records).

  - A unique combination of Monitoring Site ID (e.g., 7-21) and Mobilization ID (e.g., 2003-01) found in the Sample Event Descriptions worksheet or data table must be represented by at least one record in the Sample Descriptions worksheet or data table having the same Monitoring Site ID/Mobilization ID pair.

- **Do not report analytical results for blanks, duplicates, or other QA/QC samples. Report only values from environmental samples that have been QA/QC'ed.**

GENERAL INSTRUCTIONS (CONTINUED)

- **Submit Caltrans data exactly in the format specified by these data-reporting protocols.**

  All Caltrans "Electronic Data Deliverables" (EDD) must be submitted in the format described in this document. All Excel worksheets or Access data tables submitted by data providers must be formatted according to the requirements of the data fields contained within them as described in this data-reporting protocols document. To date, the **LDC Laboratory EDD Error Checker and Automated Data Validation software** does not evaluate particle/sediment data. To that end, each data reporter must enter **Sample Descriptions**, **Sampling Event Descriptions** and **Site Descriptions** data in their respective Excel worksheets or Access data tables by hand. Before submitting an EDD to the database manager, please confirm that all data entered in either a column (for Excel worksheets) or data field (for Access data tables) are appropriate for that particular field.

- **If a sample is analyzed and subsequently deemed not to be representative of the monitoring event from which it was collected, then the data should not be included as part of the data reporter's EDD.**

  Furthermore, if individual records or complete monitoring events are deemed invalid or unrepresentative at the end of the monitoring season, and hence excluded from analysis and discussion in a contractor's final monitoring report, then the Caltrans database manager (Mike Trouchon – Larry Walker Associates) must be notified to remove these same invalid or unrepresentative data from the Caltrans Master Stormwater Database.

- **Label all elements of each Electronic Data Deliverable (EDD) clearly**

  - The Excel workbook file or Access database file containing Sample Descriptions, Sampling Event Descriptions, and Site Descriptions data should be labeled with the name of the data reporter (consultant or university), the title of the Caltrans activity under which the data was collected, and the monitoring season (e.g., 2003-2004 or 03-04) during which the data was collected.

    File naming convention for particle/sediment data:

Particle/sediment data file	CDM Tahoe Basin Study_2003-2004 UCLA First Flush Study_03-04

  - The submittal of supporting data and documents, such as time series data, hydrographs, maps, and photographs, should be labeled with the Caltrans Monitoring Site ID and monitoring season to which they correspond. Times series data collected during storm events at a monitoring site can be submitted as multiple worksheets (one worksheet for each monitored storm event) in a single workbook that represents all times series data collected at that site during an entire monitoring season. Additionally, all hydrographs (produced by the **Caltrans Hydrograph Utility**) generated from time series data should be included as individual labeled worksheets within the workbook containing all time series data collected at a particular site over the course of the monitoring season.

File naming conventions for supporting data:

Time Series & Hydrograph file	Site 7-21 Time Series_2003-2004.xls
Map file	Site 7-21 Map_2003-2004.pdf
Photograph file	Site 7-21 Photo_2003-2004.jpeg

- When submitting an EDD to the Caltrans database manager, please compile all files (particle/sediment data, including sample, event and site descriptions, time series data and hydrographs, maps and photographs) onto one or more recordable compact discs (CD-R) labeled with the data reporter's name and date of data submittal. Mail CD(s) to the database manager at the address provided below.

- **Please notify Caltrans of any errors or inconsistencies found in this document, or any changes you might recommend.**

Definition of a Precipitation Event

For the purposes of these protocols, a precipitation event shall begin with six consecutive hours during which a sum total of at least 2.54 mm (0.1 inches) of rain falls, and end with six consecutive hours in each of which no rainfall greater than 0.25 mm (0.01 inches) of rain is recorded. The precipitation event so identified shall be truncated so that it both begins and ends in hours with rainfall equal to or greater than 0.25 mm (0.01 inches).

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1. PARTICLE/SEDIMENT SAMPLE DESCRIPTIONS

1.1. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-21
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located. Monitoring sites in a given Caltrans District numbered between 1 and 9 must be reported with a 0 (zero) in their Monitoring Site IDs (e.g., 7-09, as opposed to 7-9).

1.2. Mobilization ID

Field Type: Text
Field Size: 20 characters
Example: 2003-01
Definition: A unique, site-specific identification code assigned to the mobilization effort for a particular sampling event that occurred at a particular monitoring site.
Notes: Mobilization ID follows the format YYYY-Some combination of text and/or numbers ("Year monitoring season begins-Unique string of text and/or numbers that signify to the data provider a specific storm event that occurred at a particular monitoring site"). Even if a site is not monitored until the latter half of the monitoring season (e.g., Site X is monitored during Feb. – Apr. 2004 – the latter half of the 2003-2004 monitoring season), its Mobilization IDs include the year in which the general Caltrans monitoring season began (i.e., Mobilization IDs for samples collected at Site X would all begin with "2003").

1.3. Sample Start Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which composite sampling begins or grab sample is collected. In regard to composite samples, specifically the date on which the sampling equipment is started or deployed as in the case of sediment filters, and the flow meter begins totalizing flow if one is present.
Notes: Formatted as mm/dd/yyyy.

1.4. Sample Start Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which composite sampling begins or grab sample is collected. In regard to composite samples, specifically the time on which the sampling equipment is started or deployed, and the flow meter begin totalizing flow.
Notes: Formatted for 24-hour clock (hh:mm).

1.5. Sample End Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which composite sampling ends. Specifically, the date the sampling equipment is retrieved or the last composite sample aliquot is collected. End date is equal to Start Date for grab samples.

Notes: Formatted as mm/dd/yyyy.

1.6. Sample End Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which composite sampling ends. Specifically, the time the sampling equipment is retrieved or the last composite sample aliquot is collected. End time is equal to the Start Time for grab samples.

Notes: Formatted for 24-hour clock (hh:mm).

1.7. Sample Source

Field Type: Text
Field Size: 20 characters
Example: Storm
Definition: Identifies the source of the particle sample analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager.

<u>Standard List</u>

- Sediment - Sample from deposited or suspended sediments
- Soil - Sample from soil
- Sludge - Sample from sludge
- Solid - Sample from a solid substance that cannot be described as sediment, soil, or sludge
- Storm - Sample from storm water (rainfall) runoff
- Non-storm - Sample from non-storm water runoff
- Receiving - Sample from receiving water

1.8. Event Representation

Field Type: Text
Field Size: 20 characters
Example: Multiple
Definition: Describes the part of the event represented by the sample.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Multiple - Multiple whole storm events or a defined period of time are represented by sample; explain in Sample Notes
- Whole - Whole storm
- Discrete - One or more discrete samples collected during an event that cannot be described as representing the whole storm. This value will typically, although not exclusively, be used for a sample record having a Sample Source value equal to "Non-storm".

1.9. Sample Type

Field Type: Text
Field Size: 2 characters
Example: CG
Definition: Describes the way in which sample was collected.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- CG - Composite Sample: A sample made up of **multiple** sub-samples (soil or water) collected over some spatial or temporal scale.
- CW - Composite Sample: A sample representing an entire sediment deposit; it can represent an individual event or a specific period of time.
- G - Grab Sample: A single sample that represents conditions at a distinct point in time or point in a sediment or soil deposit. All grab samples should be reported with Sample Start Date and Sample Start Time values equal to their Sample End Date and Sample End Time values.

1.10. Sample Matrix

Field Type: Text
Field Size: 10 characters
Example: Sediment
Definition: Matrix from which sample was analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Sediment
- Soil
- Sludge
- Solid
- Water

1.11. Constituent Type

Field Type: Text
Field Size: 4
Example: CON
Definition: Describes the type or class of constituent analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- CON - Conventionals
- HC - Hydrocarbons
- ION - Major Ions
- M - Metals
- MIC - Microbial
- MIN - Minerals
- N - Nutrients
- PCB - Polychlorinated Biphenyls (PCBs)
- PEST - Pesticides
- SVOC - Semi-volatile Organic Compounds
- VOC - Volatile Organic Compounds
- SPP - Sample Physical Parameters – includes the evaluation of Mass, Particle Size Fraction, Particle Count Fraction, etc. for a sample
- MISC - Miscellaneous Constituents (refer to Section 4, "Standard Constituent Names", for list of constituents classified as "Miscellaneous").

1.12. CAS Number

Field Type: Text
Field Size: 15 characters
Example: 7440-50-8
Definition: CAS Number (Chemical Abstracts Service Registry Number) or Caltrans Constituent ID number for constituent.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Refer to Section 4, "Standard Constituent Names", for the list of CAS and Caltrans Constituent ID numbers.

1.13. Constituent

Field Type: Text
Field Size: 40 characters
Example: Cu
Definition: Name of constituent as found in the Caltrans Statewide Storm Water Database.
Notes: Standardized Entry. Select value from standard list or contact database manager. Please note that a comprehensive list of mineral constituents has yet to be developed for Caltrans particle/sediment monitoring. Data providers must report a mineral constituent (e.g., Calcium Fluoride, Kryolite, Ulexite, etc.) exactly as the analyzing laboratory reports it, even if the particular constituent does not appear on the list of "Standard Constituent Names" (refer to Section 4).

Standard List

- Refer to Section 4 – "Standard Constituent Names".

1.14. Fraction

Field Type: Text
Field Size: 6 characters
Example: Total
Definition: Describes fraction of constituent analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager. THIS DATA FIELD CAN NO LONGER BE LEFT BLANK/NULL.

Standard List

- Total - Total fraction (used for all metals, potassium, barium, manganese, ammonia (NH3-N), orthophosphate, phosphorus, and TKN).
- TR - Total recoverable fraction (used for metals only).
- N/A - All constituents other than those specified above should receive a value of "N/A" (not applicable) to describe their fraction analyzed.

1.15. Grain Size Fraction

Field Type: Text
Field Size: 20 characters
Example: < 50, 50-100
Definition: Particle diameter used in grain size distribution analysis (number or mass) or the range of grain sizes represented in a sample analyzed for the chemical content.
Notes: Units are in either percentage (of total number or weight) or microns (particle diameter). In instances where the entire sample is analyzed without any determination of grain size fraction, this data field should be populated with the default value "**Entire**". For example, the Constituent "Mass" would have a Grain Size Fraction value equal to "Entire".

1.16. Numerical Qualifier

Field Type: Text
Field Size: 1 character
Example: <
Definition: An indication of what the Reported Value for an analyzed sample represents (i.e., a minimum, maximum or "exact" value).
Notes: Standardized Entry. Select value from standard list or contact database manager. Please refer to Overall Qualifier (see data field 1.17. below) for additional guidance on the appropriate qualification of particle/sediment results.

Standard List

- < - Actual value of analyzed sample is less than reported value. This symbol must be used for all "non-detect" samples.
- = - Value of analyzed sample is as reported.
- > - Actual value of analyzed sample is greater than reported value.

1.17. Reported Value

Field Type: Numeric
Field Size: N/A
Example: 0.25
Definition: Reported laboratory result of analyzed sample.
Notes: Reported Value must equal Reporting Limit if associated Numerical Qualifier is "<".

1.18. Overall Qualifier

Field Type: Text
Field Size: 4 characters
Example: U
Definition: An overall data validation qualifier based on lab results and associated quality assurance/quality control (QAQC) analyses.
Notes: Standardized Entry. Select value from standard list or contact database manager. The qualifiers and definitions presented below represent a compilation of data qualifiers used by specific EPA programs as noted in: (1) *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 1994); and (2) *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999).

<u>Standard List</u>

- U - The material was analyzed for, but was not detected above the level of the associated value (the associated value represents a reporting limit that may or may not be elevated due to blank contamination).
- J - The associated value is approximate (i.e., an estimated quantity).
- N - The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification".
- NJ - The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
- UJ - The material was analyzed for, but was not detected. The associated value (i.e., reporting limit) is an estimate and may be inaccurate or imprecise.
- R - The sample result is rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Notes: While data reporters may include "rejected" data (data assigned an Overall Qualifier value of "R") in the EDDs they provide to the Caltrans database manager, these data are <u>not</u> imported into the Caltrans Master Stormwater Database at the end of each monitoring season.

1.19. Units

Field Type: Text
Field Size: 12 characters
Example: mg/kg
Definition: Describes the unit of measure associated with the Reported Value.
Notes: Standardized Entry. Select value from standard list or contact database manager. Report sample results in the appropriate unit associated with a particular constituent as specified in "Standard Constituent Names" (see Section 4). Confirm that values for Reported Value, Method Detection Limit, and Reporting Limit are all reported in the same units for individual sample records.

Standard List

- #/L
- %
- µg/kg
- mg/kg
- g
- mg/L
- pcf - Unit associated with the constituent "Dry Density"

1.20. Leachate Method

Field Type: Text
Field Size: 5 characters
Example: WET
Definition: Describes the leachate method used when constituent concentration is reported on a leachate. Sample constituent concentrations not reported on a leachate should have this data field value reported as "N/A".
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- DIWET - De-ionized Water Waste Extraction Test
- WET - Waste Extraction Test
- TCLP - Toxicity Characteristic Leaching Procedure
- SPLP - Synthetic Precipitation Leaching Procedure
- STLC - Soluble Threshold Leachate Concentration

Alternate Value: - N/A (see Definition above).

1.21. Preparation Method

Field Type: Text
Field Size: 40 characters
Example: Separatory Funnel
Definition: Describes the preparation a sample underwent prior to analysis. All samples receiving no form of preparation prior to analysis should have this data field value reported as "None".
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Autoclave
- Drying - for sediment samples
- Hot Plate
- Microwave
- Purge and Trap
- Methanol Extraction
- Continuous
- Separatory Funnel
- Soxhlet
- Ultrasonic Extraction
- Solid Phase Extraction - for water samples
- Accelerated Solvent Extraction

Alternate Value: - None (see Definition above).

1.22. Method Reference

Field Type: Text
Field Size: 12 characters
Example: EPA
Definition: Provides the reference for the analytical method used to evaluate the sample.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- EPA - US Environmental Protection Agency.
- SM - Standard Methods.
- Field Probe - Constituent evaluated in the field using a self-contained analytical instrument. Note: no Method Numbers are associated with field-measured constituents.
- Caltrans - Caltrans-defined analytical method.
- ASTM - American Society for Testing and Materials
- EZ - Electrozone particle counting method
- LD - Laser diffraction particle counting method
- SEM - Scanning electron microscope particle counting method
- XD - X-ray diffraction mineral content identification method
- OM - Optical microscopy mineral content identification method
- EM - Electron microprobe mineral content identification method

1.23. Method Number

Field Type: Text
Field Size: 16 characters
Example: 625
Definition: Reference number for the analytical method used to evaluate the sample.
Notes: By convention, method numbers that contain a text suffix do not include a space between the number and the text suffix (e.g., 6010A).

Alternate Value: - N/A (appropriate to use this value when Method Reference value is equal to "Field Probe").

1.24. Method Detection Limit

Field Type: Numeric
Field Size: N/A
Example: 0.2
Definition: Method Detection Limit (MDL) – The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from the analysis of a sample in a given matrix containing the analyte.
Notes: Concentrations and values reported by a laboratory that are between the MDL and Reporting Limit (see data field 1.23. below) are usually flagged by the laboratory as estimated "J", indicating that the constituent is present but its concentration or value cannot be accurately quantified (see data field 1.17, Overall Qualifier, for further information on data validation qualifiers).

1.25. Reporting Limit

Field Type: Numeric
Field Size: N/A
Example: 1.0
Definition: Reporting Limit (RL) as reported by laboratory. This value is the lowest concentration or value of a constituent that can be reliably quantified within specified limits of precision and accuracy during routine laboratory operating conditions. Reporting Limit is equivalent to Practical Quantitative Limit (PQL) and Reported Detection Limit (RDL).
Notes: The RL may be elevated above the Caltrans "target" RL due to matrix interference.

1.26. Collection Method

Field Type: Text
Field Size: 8 characters
Example: Auto
Definition: Describes the way in which a sample was collected.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Auto - Sample collected by automated sampling device.
- Manual - Sample collected manually.
- Passive - Passive sediment collection system

1.27. Field Sample ID

Field Type: Text
Field Size: 35 characters
Example: 134-0010-281500A
Definition: Field identification number assigned to sample/sample vessel.
Notes: This data field can contain any combination of text and numeric characters.

1.28. Lab Name

Field Type: Text
Field Size: 25 characters
Example: APPL
Definition: Name of laboratory that analyzed sample.
Notes: Standardized Entry. Select value from standard list. The list of analytical laboratories used by the Caltrans Storm Water Management Program will likely change over time, and therefore the Standard List below might not include the name of every laboratory used in any given monitoring year. If the name of a laboratory used to analyze samples does not appear in the list below, simply report the name of the laboratory in this data field. The database manager will notice the *new* laboratory name during routine data validation and will add it to the Standard List below in a subsequent version of this document.

Standard List

- ASI - Analytical Services, Inc.
- APPL - Agriculture & Priority Pollutants Labs
- Associated Labs
- CEL - Calscience Environmental Labs
- DMA - Del Mar Analytical
- Evergreen - Evergreen Analytical
- GeoAnalytical Labs
- Geotesting Express
- Goodson - Goodson & Associates, Inc.
- Micromeritics
- North Coast Labs
- Pat-Chem
- Quanterra
- Soil Control Lab
- ToxScan

1.29. Lab Sample ID

Field Type: Text
Field Size: 25 characters
Example: 120085-400A
Definition: Laboratory identification number assigned to sample by analytical laboratory.
Notes: This data field can contain any combination of text and numeric characters.

1.30. Contract Number

Field Type: Text
Field Size: 12 characters
Example: 43A005
Definition: Caltrans contract number under which sample was collected.
Notes: This data field can contain any combination of text and numeric characters.

1.31. Task Order Number

Field Type: Text
Field Size: 6 characters
Example: 11
Definition: Caltrans task order number under which sample was collected.
Notes: This data field can contain any combination of text and numeric characters.

1.32. Sample Notes

Field Type: Text
Field Size: 255 characters
Example: Sample End Time missing due to malfunctioning automated sampler.
Definition: This data field contains any notes or remarks about the sample or various data fields used to describe the sample.
Notes: Data reporter should provide a note for any data field left blank (with the exception of Overall Qualifier). It is not appropriate to provide a note in a particular cell of a data field other than Sample Notes. Considering the example above, it is not appropriate to place the note, "Sample End Time missing due to malfunctioning automated sampler", in the Sample End Time data field. The note must be entered into the Sample Notes data field.

2. PARTICLE/SEDIMENT SAMPLING EVENT DESCRIPTIONS

Some information listed in this section may not be relevant for some particle/sediment monitoring if the sampling is not precipitation event driven. See "General Instructions" page iii for details on which data fields are relevant to "Non-storm" sampling, or contact database manager for further information.

2.1. Mobilization ID

Field Type: Text
Field Size: 20 characters
Example: 2003-01
Definition: A unique, site-specific identification code assigned to the mobilization effort for a particular sampling event that occurred at a particular monitoring site.
Notes: Mobilization ID follows the format YYYY-Some combination of text and/or numbers ("Year monitoring season begins-Unique string of text and/or numbers that signify to the data provider a specific storm event that occurred at a particular monitoring site"). Even if a site isn't monitored until the latter half of the monitoring season (e.g., Site X is monitored during Feb. – Apr. 2004 – the latter half of the 2003-2004 monitoring season), its Mobilization IDs include the year in which the general Caltrans monitoring season began (i.e., Mobilization IDs for samples collected at Site X would all begin with "2003").

2.2. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-21
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located. Monitoring sites in a given Caltrans District numbered between 1 and 0 must be reported with a 0 (zero) in their Monitoring Site IDs (e.g., 7-09, as opposed to 7-9).

2.3. Event Type

Field Type: Text
Field Size: 10 characters
Example: Non-storm
Definition: Describes if sampling event is associated with a storm event or a non-storm event.
Notes: Standardized Entry. Select value from standard list or contact database manager. This data field quickly describes whether an event record includes precipitation and flow data (i.e., event is a storm event) or does not necessarily include such precipitation and flow data (i.e., event is a non-storm event, such as a dry weather sampling event; note: flow data could be provided for a dry weather event). Storm event records that are missing various precipitation and flow data due to malfunctioning equipment must be described with Event Type equal to "Storm" and include remarks in their Event Notes data field as to why certain data are missing.

Standard List

- Storm
- Non-storm

2.4. Rain Start Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which precipitation event begins. See "Definition of a Precipitation Event" in the General Instructions section of this document.
Notes: Formatted as mm/dd/yyyy.

2.5. Rain Start Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which precipitation event begins. See "Definition of a Precipitation Event" in the General Instructions section of this document.
Notes: Formatted for 24-hour clock (hh:mm).

2.6. Rain End Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which precipitation event ends. See "Definition of a Precipitation Event" in the General Instructions section of this document.
Notes: Formatted as mm/dd/yyyy.

2.7. Rain End Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which precipitation event ends. See "Definition of a Precipitation Event" in the General Instructions section of this document.
Notes: Formatted for 24-hour clock (hh:mm).

2.8. Event Rain (mm)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 15.99
Definition: Total rain at site for an event in millimeters (mm).
Notes: The Site Descriptions data field named Rain Record Source identifies the source of the Event Rain data for a particular monitoring site. See "Definition of a Precipitation Event" in the General Instructions section of this document.

2.9. Max Intensity (mm/hr)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 12.18
Definition: Peak 5-minute intensity of a storm event in millimeters/hour (mm/hr).
Notes: Maximum Intensity is calculated as twelve times (12 x) the maximum rainfall recorded in any 5-minute period.

2.10. Antecedent Dry (days)

Field Type: Numeric
Field Size: Provide number only to one (1) decimal place.
Example: 12.0
Definition: Days since the end of the most recent prior Caltrans-defined precipitation event (whether monitored or not). If datum exists, irrespective of whether the prior event was monitored, data reporter should include Antecedent Dry datum as part of the Event Record for the current event.
Notes: See "Definition of a Precipitation Event" in the General Instructions section of this document. With reference to the first precipitation event monitored at a particular monitoring site, it might be necessary to look back in time before the start of the current monitoring season (typically Oct. 1st) to identify the last precipitation event that occurred at said site. If data exist for a precipitation event that occurred during June through September (i.e., occurred between the current and previous monitoring season), then these data should be used when calculating the Antecedent Dry value for the first precipitation event monitored during the current monitoring season.

2.11. Antecedent Event Rain (mm)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 24.37
Definition: Total rain at site for the most recent antecedent precipitation event in millimeters (mm). The antecedent precipitation event used for this data field should be the same antecedent precipitation event referenced in the Antecedent Dry data field. The quantification of Antecedent Event Rain does not include "inter-event" precipitation.
Notes: Using the examples provided above for Antecedent Dry and Antecedent Event Rain, the antecedent or prior precipitation event for Site X occurred 12.0 days ago, and delivered 24.37 mm of rainfall. The antecedent precipitation event must meet Caltrans' criteria for a precipitation event. See "Definition of a Precipitation Event" in the General Instructions section of this document.
With reference to the first precipitation event monitored at a particular monitoring site, it might be necessary to look back in time before the start of the current monitoring season (typically Oct. 1st) to identify the last precipitation event that occurred at said site. If data exist for a precipitation event that occurred during June through September (i.e., occurred between the current and previous monitoring season), then these data should be used when calculating the Antecedent Event Rain value for the first precipitation event monitored during the current monitoring season.

2.12. Peak Capture

Field Type: Text
Field Size: 1 character
Example: Y
Definition: Indication of whether peak flow was captured during sampling event.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Y - Yes, peak flow was captured.
- N - No, peak flow was not captured.

2.13. Runoff Start Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which first runoff begins.
Notes: Formatted as mm/dd/yyyy.

2.14. Runoff Start Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which first runoff begins.
Notes: Formatted for 24-hour clock (hh:mm).

2.15. Runoff End Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which last runoff ceases.
Notes: Formatted as mm/dd/yyyy.

2.16. Runoff End Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which last runoff ceases.
Notes: Formatted for 24-hour clock (hh:mm)

2.17. Total Flow Volume (L)

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 38686
Definition: Total measured flow volume in liters (L) at a monitoring site for an event.

2.18. Peak Flow (L/s)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 3.40
Definition: Estimated peak flow of runoff in liters per second (L/s) at a monitoring site for an event.

2.19. Estimated Percent Capture

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 99
Definition: Estimated percentage of total event flow volume during which monitoring was performed (i.e., while the sampler was activated and flow-proportioned sample collection was successfully occurring). Report datum only if estimate is based on actual runoff and sample collection data measured by an instrument located at the monitoring site in question.
Notes: Periods of sampler malfunction or failure to collect sample must be excluded from the "captured flow".

2.20. Cumulative Precipitation (mm)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 100.76
Definition: Estimated cumulative precipitation in millimeters (mm) at monitoring site since the beginning of the water year (October 1), up to the Rain Start Date/Time for the monitored event. All precipitation that has fallen to date at a site, including "inter-event" precipitation, should be included in the Cumulative Precipitation value reported for that site for a particular event.

2.21. Sample Collector

Field Type: Text
Field Size: 25 characters
Example: Roy Estrada
Definition: Name of the individual who collected the sample.

2.22. Organization

Field Type: Text
Field Size: 30 characters
Example: Acme Environmental
Definition: Organization to which the sample collector is associated.

2.23. Event Notes

Field Type: Text
Field Size: 255 characters
Example: Runoff End Time missing due to malfunctioning flow meter.
Definition: This data field contains any notes or remarks about the sampling event or various data fields used to describe the sampling event.
Notes: Data reporter should provide a note for any data field left blank. It is not appropriate to provide a note in a particular cell of a data field other than Event Notes. Considering the example above, it is not appropriate to place the note, "Runoff End Time missing due to malfunctioning flow meter", in the Runoff End Time data field. The note must be entered into the Event Notes data field.

3. PARTICLE/SEDIMENT MONITORING SITE DESCRIPTIONS

3.1. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-21
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located. Monitoring sites in a given Caltrans District numbered between 1 and 9 must be reported with a 0 (zero) in their Monitoring Site IDs (e.g., 7-09, as opposed to 7-9).

3.2. Monitoring Year

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 2003
Definition: Identifies the monitoring season a site is monitored by populating the data field with the year the current monitoring season begins.
Notes: In regard to the 2003-2004 monitoring season, the Monitoring Year value for each site monitored would be "2003" – the year the current monitoring season began. The term Monitoring Year refers to only a single calendar year, while the term Monitoring Season necessarily refers to two calendar years, such as 2003-2004.

3.3. Site Name

Field Type: Text
Field Size: 100 characters
Example: DICE Site 12/23
Definition: Name of monitoring site.
Notes: Site Name is meant to be a shorthand designation for the monitoring site, and the "common name" by which the sampling crew and data reporter refer to the site.

3.4. Site Description

Field Type: Text
Field Size: 255 characters
Example: East of Ocean View Avenue Onramp to EB 210 Fwy; a low-density residential site within foothills.
Definition: Describes monitoring site in some detail, including observations related to site's location and physical characteristics.
Notes: In addition to the above definition, this field can be used to describe changes observed at the site since the prior monitoring season.

3.5. Caltrans District

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 7
Definition: Caltrans district in which monitoring site is located.

3.6. Hydrologic Sub-Area

Field Type: Numeric
Field Size: Provide 5-digit number in the format XXX.XX
Example: 405.32
Definition: State Water Resources Control Board (SWRCB) Hydrologic Unit Sub-Area in which monitoring site is located.
Notes: SWRCB Hydrologic codes are 6-byte strings composed of numbers and a decimal point. The meaning associated with each byte position is shown below.

Byte(s)	Meaning
1	Hydrologic Region
2, 3	Hydrologic Unit
4	Decimal point
5	Hydrologic Area
6	Hydrologic Sub-Area

Hydrologic sub-areas are typically identified in Basin Plans. They may also be found at the Water Quality Standards Inventory Database web site: http://endeavor.des.ucdavis.edu/wqsid/region.asp

3.7. County

Field Type: Text
Field Size: 25 characters
Example: Los Angeles
Definition: County in which monitoring site is located.
Notes: It is not necessary to include the word "County" along with the actual name of the county in which the monitoring site is located.

3.8. RWQCB

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 4
Definition: Regional Water Quality Control Board (RWQCB) region in which monitoring site is located.

3.9. Runoff Characterization

Field Type: Text
Field Size: 25 characters
Example: Hwy
Definition: Type of runoff characterized by samples collected from monitoring site.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Hwy - Highway or Freeway
- Maintenance - Maintenance facility
- Parking - Parking lot (e.g., Park & Ride facility)
- Rest Area - Rest area
- Free-Flowing - Free-flowing traffic area
- Congested - Congested traffic area
- Construction - Construction
- BMP - Site designed for storm water treatment
- Border Check-point - Border Check-point
- Bridge - Bridge
- CVIF - Commercial Vehicle Inspection Facility
- Erosion - Erosion study
- Receiving - Receiving water (described further in "Receiving Water Type)
- Toll Plaza - Toll Plaza
- Watershed - Urban or rural watershed (described further in "Land Use")

3.10. Surface Type

Field Type: Text
Field Size: 25 characters
Example: Asphalt
Definition: Describes the predominant surface type associated with a Caltrans facility.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Landscape - Landscaping
- Asphalt - Asphalt only
- Concrete - Concrete only
- Asphalt/Concrete - Mixture of asphalt and concrete
- Right-of-Way - Right-of-Way (includes landscape, asphalt and/or concrete)
- Construction Site - Graded construction site

3.11. Land Use

Field Type: Text
Field Size: 4 characters
Example: R
Definition: Predominant land use of the tributary catchment area. This field describes the predominant land use of the area from which sampled runoff originates.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- R - Residential
- C - Commercial
- I - Industrial
- A - Agricultural
- F - Forest
- O - Open
- T - Transportation Facility (e.g., bridge, county road, highway, etc.)
- M - Mixed (no predominant land use can be discerned)

3.12. Catchment Area (ha)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 2.91
Definition: Total surface area in hectares (ha) draining to the point of collection of the storm water runoff sample.

3.13. Impervious Fraction

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 0.67
Definition: Estimated fraction of the catchment area that is effectively impervious. Impervious Fraction values will range from 0 – 1.

3.14. BMP Type

Field Type: Text
Field Size: 50 characters
Example: EDB
Definition: Describes the type of BMP represented by the monitoring site. This data field to be populated only for monitoring sites designed to treat storm water runoff. All non-BMP sites should have this data field value reported as "N/A".
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Retention - Retention Pond
- Swale - Biofiltration Swale
- EDB - Extended Detention Basin
- Wet Pond - Wet Detention Pond
- Dry Pond - Extended Dry Detention Pond
- Compost - Compost Media Filter
- Zeolite - Zeolite Media Filter
- SF - Sand Media Filter
- IB - Infiltration Basin
- IT - Infiltration Trench
- TCB - Trapping Catch Basin
- Insert - Drain Inlet Insert
- Strip - Biofiltration Strip
- Strip-Trench - Filtration Strip and Infiltration Trench Treatment Train
- Silt Fence - Silt Fence
- Gravel Bags - Gravel Bags (commonly used at construction sites)
- Sand Bags - Sand Bags (commonly used at construction sites)
- Straw Bales - Straw Bales (commonly used at construction sites)
- OWS - Oil/Water or Debris Separator
- MCTT - Mult-chambered Treatment Train
- CDS - Continuous Deflector Separator
- DBST - Double-Barrel Sand Trap
- DISump - Drain Inlet with Sump
- Wetland - Natural or man-made wetland
- DIC - Drain Inlet Cleaning
- Pickup - Litter Pickup (gross solids studies)
- Sweep - Street Sweeping (gross solids studies)
- ModifyIn - Modified Inlet (gross solids studies)
- Grate - Bicycle Grate/LID (gross solids studies)
- ModGrate - Modified Bicycle Grate (gross solids studies)
- Baffle Box - Baffle Box (gross solids studies)
- FSVS - Forward Sloping V Screen (gross solids studies)
- RSVS - Reverse Sloping V Screen (gross solids studies)
- IBS - Inclined Bar Screen (gross solids studies)
- LRD - Linear Radial Device (gross solids studies)

Alternate Value: - N/A (see Definition above).

3.15. Point of Collection

Field Type: Text
Field Size: 20 characters
Example: Discharge
Definition: Describes the point of sample collection at the monitoring site.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Discharge - Outfall to receiving water or outlet to conveyance system
- Inlet - Inlet to BMP
- Outlet - Outlet to BMP
- Within - Somewhere within BMP
- Bypass - Bypass structure associated with BMP
- Overflow - Overflow structure associated with BMP
- Overland - Overland flow
- Receiving - Location(s) in receiving water (stream, lake, etc.)

3.16. Control Site

Field Type: Text
Field Size: 25 characters
Example: 7-156
Definition: The Caltrans Monitoring Site ID for the control or BMP "inlet" site associated with the BMP "outlet" or BMP "within" site in question. All non-BMP sites and BMP "inlet" sites should have this data field value reported as "N/A".
Notes: A small number of BMP sites do not possess a control or reference site. These sites should have this data field populated with the value "No Control for BMP".

Alternate Values: - N/A (see Definition above).
- No Control for BMP (see Notes above).

3.17. Cut-Fill

Field Type: Text
Field Size: 15 characters
Example: Cut
Definition: Identifies the roadway or facility as a cut, fill, grade or hybrid type (e.g., Grade/Fill) site.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Cut - Sample collected from a cut area.
- Fill - Sample collected from a fill area.
- Grade - Sample collected from a grade area.
- Cut/Fill - Sample collected from a roadway or facility with both cut and fill areas.
- Grade/Cut - Sample collected from a roadway or facility with both grade and cut areas.
- Grade/Fill - Sample collected from a roadway or facility with both grade and fill areas.

3.18. Roadway Post Mile

Field Type: Text
Field Size: 18 characters
Example: I-210-EB-18.45
Definition: A four-part descriptor that describes the roadway type, roadway number, traffic direction, and post mile of the Caltrans highway facility nearest to the monitoring site. If no such Post Mile exists for a site, the data field value should be reported as "N/A".
Notes: The Roadway Post Mile value is a compilation of the following four pieces of information: **Roadway Type-Roadway Number-Traffic Direction-Post Mile**
Standardized entries exist for roadway type and traffic direction.
Select values from standard lists or contact database manager.

Standard Lists

Roadway Type

- I - Interstate
- SR - State Route
- CR - County Road

Traffic Direction

- EB - Eastbound
- WB - Westbound
- NB - Northbound
- SB - Southbound

Alternate Value: - N/A (see Definition above).

3.19. Latitude

Field Type: Numeric
Field Size: Provide number to five (5) decimal places.
Example: 34.20969
Definition: Latitude of monitoring site in decimal degrees to five (5) decimal places.
Notes: Data should be collected using a differential GPS instrument with sufficient accuracy to report degrees to five decimal places.

3.20. Longitude

Field Type: Numeric
Field Size: Provide number to five (5) decimal places.
Example: 118.22469
Definition: Longitude of monitoring site in decimal degrees to five (5) decimal places.
Notes: Data should be collected using a differential GPS instrument with sufficient accuracy to report degrees to five decimal places

3.21. Datum

Field Type: Text
Field Size: 20 characters
Example: NAD 83
Definition: Datum by which latitude and longitude reported.

3.22. Rain Record Source

Field Type: Text
Field Size: 50 characters
Example: NOAA
Definition: Source of precipitation record used in precipitation estimates.
Notes: Report "Onsite" if rain gauge is located at the monitoring site, or report the name/location of the nearest rain gauge. Actual precipitation event record (i.e., rainfall data from rain gauge) should be included in a Time Series worksheet for the event (see Time Series data field description in this section).

3.23. Receiving Water Type

Field Type: Text
Field Size: 20 characters
Example: Intermittent
Definition: Type of receiving water sampled or into which storm water runoff is discharged.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Intermittent - Intermittent or seasonal stream or channel
- Wetlands - Seasonal or perennial wetlands
- River - Perennial freshwater river
- Stream - Perennial freshwater stream
- Lake - Freshwater lake or impoundment
- Pond - Freshwater pond
- Bay - Salt or brackish water bay
- Estuary - Salt or brackish water estuary
- Groundwater - Runoff percolates into soil profile surrounding monitoring site and ostensibly enters groundwater
- Ocean

3.24. AADT

Field Type: Numeric
Field Size: N/A
Example: 120000
Definition: Average annual daily traffic (AADT) flow at or near monitoring site.
Notes: If site is a maintenance yard, parking lot, or rest area, report the estimated number of vehicles entering and leaving the facility each day. Note that Southbound or Westbound traffic counts are usually represented by the "Back AADT" number provided in the AADT database, whereas the Northbound or Eastbound traffic counts are usually represented by the "Ahead AADT" number. For more information, please visit the following Caltrans web page:

http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/2002all.htm

3.25. AADT Source

Field Type: Text
Field Size: 100 characters
Example: http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/2003all.htm
Definition: Source or reference for reported AADT value.
Notes: A searchable AADT database is available at the Caltrans Traffic and Vehicle Data Systems Unit web page:

http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/

Note that Southbound or Westbound traffic counts are usually represented by the "Back AADT" number provided in the AADT database, whereas the Northbound or Eastbound traffic counts are usually represented by the "Ahead AADT" number.

3.26. Adjacent Lanes

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 2
Definition: The number of traffic lanes adjacent to the monitoring site that contribute storm water runoff that is sampled at the monitoring site's point of collection.
Notes: In many cases, the numeric value populating this data field will be a summation of the number of lanes of traffic moving in one direction only next to the monitoring site.

This data field need only be populated for HIGHWAY monitoring sites (i.e., monitoring sites having Runoff Characterization = "Hwy")

3.27. Total Lanes

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 4
Definition: The total number of traffic lanes (traffic moving in both directions) neighboring the monitoring site.
Notes: This data field should specify all lanes of traffic near the monitoring site that may impact storm water runoff through the deposition of airborne pollutants.

This data field need only be populated for HIGHWAY monitoring sites (i.e., monitoring sites having Runoff Characterization = "Hwy")

3.28. Time Series

Field Type: Text
Field Size: 75 characters
Example: Site 7-21 Time Series_2003-2004.xls
Definition: The name of the Excel worksheet in which time series data (flow, precipitation, etc.) collected at a monitoring site is submitted.
Notes: Times series data collected during storm events at a monitoring site can be submitted as multiple worksheets (one worksheet for each storm event) in a single workbook that represents all times series data collected at that site during an entire monitoring season. The Excel workbook file should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2003-2004 or 03-04) to which it corresponds.

3.29. Map

Field Type: Text
Field Size: 50 characters
Example: Site 7-21 Map_2003-2004.pdf
Definition: The name of the electronic document containing a map that shows the location of the monitoring site.
Notes: The actual electronic document containing a map of the monitoring site should be submitted along with the rest of the data collected for the site, including particle/sediment data, time series data, and one or more photographs. The map should contain the clearly marked location of the monitoring site, latitude and longitude markers, and the watershed contributing flows to the site. The electronic map document should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2003-2004 or 03-04) to which it corresponds.

3.30. Photograph

Field Type: Text
Field Size: 100 characters
Example: Site 7-21 Photo_2003-2004.jpeg
Definition: The name of the electronic document containing photograph(s) of the monitoring site.
Notes: The actual electronic document containing photograph(s) of the monitoring site should be submitted along with the rest of the data collected for the site, including particle/sediment data, time series data, and a map. The electronic photograph document should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2003-2004 or 03-04) to which it corresponds.

3.31. Site Notes

Field Type:	Text
Field Size:	255 characters
Example:	No AADT value provided for this site. Site is located along a county road for which no AADT data are available.
Definition:	This data field contains any notes or remarks about the monitoring site or various data fields used to describe the monitoring site.
Notes:	Data reporter should provide a note for any data field left blank. It is not appropriate to provide a note in a particular cell of a data field other than Site Notes. Considering the example above, it is not appropriate to place the note, "No AADT value provided for this site. Site is located along a county road for which no AADT data are available", in the AADT data field. The note must be entered into the Site Notes data field.

4. STANDARD CONSTITUENT NAMES

4.1. Metals (µg/kg or mg/kg for particle/sediment results, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Al	7429-90-5	Fe	7439-89-6
Sb	7440-36-0	Pb	7439-92-1
As	7440-38-2	Hg	7439-97-6
Be	7440-41-7	Mo	7439-98-7
Cd	7440-43-9	Ni	7440-02-0
Cr	7440-47-3	Se	7782-49-2
Cr (III)	16065-83-1	Ag	7440-22-4
Cr (VI)	18540-29-9	Tl	7440-28-0
Co	7440-48-4	V	7440-62-2
Cu	7440-50-8	Zn	7440-66-6

4.2. Nutrients (mg/kg for particle/sediment results, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
NH3-N	7664-41-7	Ortho-P	CT-ORTHOP
NO2-N	14797-65-0	P	7723-14-0
NO3-N	14797-55-8	TKN	CT-TKN
Organic Nitrogen	CT-ORGN	Total N	CT-TN

4.3. Conventionals (mg/L, typically – unless noted)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Settleable Solids	CT-SETSOL	TSS	CT-TSS
SSC	CT-SSC	Turbidity (NTU)	CT-TURB
TDS	CT-TDS	Turbidity, filtered (NTU)	CT-TURBFLT
TOC	CT-TOC	TVSS	CT-TVSS

4.4. Major Ions (mg/kg for particle/sediment results, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Ca	7440-70-2	K	7440-09-7
Cl	16887-00-6	Mg	7439-95-4
CO3	CT-CO3	Na	7440-23-5
HCO3	CT-HCO3	SO4	14808-79-8

4.5. Minerals (mg/kg for particle/sediment results, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Asbestos	1332-21-4	Fluoride	CT-FLUORIDE
B	7440-42-8	Mn	7439-96-5
Ba	7440-39-3	Silica	7631-86-9

Please note that a comprehensive list of mineral constituents has yet to be developed for Caltrans particle/sediment monitoring. Data providers must report a mineral constituent (e.g., Calcium Fluoride, Kryolite, Ulexite, etc.) exactly as the analyzing lab reports it, even if the particular constituent does not appear in the brief list of minerals noted above. As particle/sediment monitoring efforts continue, Caltrans will develop an expanded list of mineral constituents based on the results of mineral content analyses performed on particle/sediment samples collected by the Program.

4.6. VOCs (EPA 8260, 601, 602, 603, 1624; µg/kg for particle results, typically)

Constituent	CAS or Caltrans ID #
1,1,1,2-Tetrachloroethane	630-20-6
1,1,1-Trichloroethane	71-55-6
1,1,2,2-Tetrachloroethane	79-34-5
1,1,2-Trichloroethane	79-00-5
1,1-Dichloroethane	75-34-3
1,1-Dichloroethylene	75-35-4
1,1-Dichloropropene	563-58-6
1,2,3-Trichlorobenzene	87-61-6
1,2,3-Trichloropropane	96-18-4
1,2,4-Trimethylbenzene	95-63-6
1,2-Dibromo-3-chloropropane	96-12-8
1,2-Dibromoethane	106-93-4
1,2-Dichlorobenzene	95-50-1
1,2-Dichloroethane	107-06-2
1,2-Dichloropropane	78-87-5
1,3,5-Trimethylbenzene	108-67-8
1,3-Dichlorobenzene	541-73-1
1,3-Dichloropropane	142-28-9
1,3-Dichloropropene	542-75-6
1,4-Dichlorobenzene	106-46-7
2,2-Dichloropropane	594-20-7
2-Butanone	78-93-3
2-Chloroethylvinyl ether	110-75-8
2-Chlorotoluene	95-49-8
2-Hexanone	591-78-6
4-Bromofluorobenzene	460-00-4
4-Chlorotoluene	106-43-4
4-Methyl-2-pentanone (MIBK)	108-10-1
Acetone	67-64-1
Acrolein	107-02-8
Acrylonitrile	107-13-1
Benzene	71-43-2
Benzyl chloride	100-44-7
Bromobenzene	108-86-1
Bromochloromethane	74-97-5
Bromoform	75-25-2
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chlorodibromomethane	124-48-1
Chloroethane	75-00-3

Constituent	CAS or Caltrans ID #
Chloroform	67-66-3
cis-1,2-Dichloroethene	156-59-2
cis-1,3-Dichloropropene	10061-01-5
cis-1,4-Dichloro-2-butene	1476-11-5
Dibromofluoromethane	1868-53-7
Dibromomethane	74-95-3
Dichlorobromomethane	75-27-4
Dichlorodifluoromethane	75-71-8
Ethanol	64-17-5
Ethylbenzene	100-41-4
Iodomethane	74-88-4
Isopropylbenzene	98-82-8
Methanol	67-56-1
Methyl bromide	74-83-9
Methyl chloride	74-87-3
Methylene chloride	75-09-2
Methyl-t-butyl ether (MTBE)	1634-04-4
m-Xylene	108-38-3
m,p-Xylenes	CT-XYLENES-M-P
n-Butylbenzene	104-51-8
n-Propylbenzene	103-65-1
o-Xylene	95-47-6
Pentachloroethane	76-01-7
p-Isopropyltoluene	99-87-6
p-Xylene	106-42-3
Pyridine	110-86-1
sec-Butylbenzene	135-98-8
Styrene	100-42-5
tert-Butylbenzene	98-06-6
Tetrachloroethylene (PCE)	127-18-4
Tetrahydrofuran	109-99-9
Toluene	108-88-3
trans-1,2-Dichloroethene	156-60-5
trans-1,3-Dichloropropene	10061-02-6
trans-1,4-Dichloro-2-butene	110-57-6
Trichloroethylene (TCE)	79-01-6
Trichlorofluoromethane	75-69-4
Vinyl acetate	108-05-4
Vinyl chloride	75-01-4
Xylenes (total)	1330-20-7

4.7. SVOCs (EPA 8250/8270, 625; µg/kg for particle results, typically)

Constituent	CAS or Caltrans ID #
1,2,4-Trichlorobenzene	120-82-1
1,2-Diphenylhydrazine	122-66-7
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2
2,4-Dichlorophenol	120-83-2
2,4-Dimethylphenol	105-67-9
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2,6-Dichlorophenol	87-65-0
2,6-Dinitrotoluene	606-20-2
2-Chloronaphthalene	91-58-7
2-Chlorophenol	95-57-8
2-Methyl-4,6-dinitrophenol	534-52-1
2-Methylnaphthalene	91-57-6
2-Methylphenol (o-Cresol)	95-48-7
2-Nitroaniline	88-74-4
2-Nitrophenol	88-75-5
3,3′-Dichlorobenzidine	91-94-1
3-Methyl-4-chlorophenol	59-50-7
3-Methylphenol (m-Cresol)	108-39-4
3-Nitroaniline	99-09-2
4-Bromophenyl phenyl ether	101-55-3
4-Chloroaniline	106-47-8
4-Chlorophenyl phenyl ether	7005-72-3
4-Methylphenol (p-Cresol)	106-44-5
4-Nitroaniline	100-01-6
4-Nitrophenol	100-02-7
Acenaphthene	83-32-9
Acenaphthylene	208-96-8
Aniline	62-53-3
Anthracene	120-12-7
Benzidine	92-87-5
Benzo(a)anthracene	56-55-3
Benzo(a)pyrene	50-32-8
Benzo(b)fluoranthene	205-99-2
Benzo(ghi)perylene	191-24-2

Constituent	CAS or Caltrans ID #
Benzo(k)fluoranthene	207-08-9
Benzoic acid	65-85-0
Benzyl alcohol	100-51-6
Bis(2-chloroethoxy)methane	111-91-1
Bis(2-chloroethyl)ether	111-44-4
Bis(2-chloroisopropyl)ether	39638-32-9
Bis(2-ethylhexyl)phthalate	117-81-7
Butylbenzyl phthalate	85-68-7
Carbazole	86-74-8
Chrysene	218-01-9
Dibenzo(a,h)anthracene	53-70-3
Dibenzofuran	132-64-9
Diethyl phthalate	84-66-2
Dimethyl phthalate	131-11-3
Di-n-Butyl phthalate	84-74-2
Di-n-Octyl phthalate	117-84-0
Endrin ketone	53494-70-5
Fluoranthene	206-44-0
Fluorene	86-73-7
Hexachlorobenzene	118-74-1
Hexachlorobutadiene	87-68-3
Hexachlorocyclopentadiene	77-47-4
Hexachloroethane	67-72-1
Indeno(1,2,3-cd)pyrene	193-39-5
Isophorone	78-59-1
Naphthalene	91-20-3
Nitrobenzene	98-95-3
N-Nitrosodimethylamine	62-75-9
N-Nitrosodi-N-propylamine	621-64-7
N-Nitrosodiphenylamine	86-30-6
PAHs	CT-PAH
Pentachlorophenol	87-86-5
Phenanthrene	85-01-8
Phenol	108-95-2
Phenolics	CT-PHENOLICS
Pyrene	129-00-0

4.8. OC Pesticides (EPA 8080/8081; µg/kg for particle results, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
4,4′-DDD	72-54-8	Dieldrin	60-57-1
4,4′-DDE	72-55-9	Endosulfan sulfate	1031-07-8
4,4′-DDT	50-29-3	Endrin	72-20-8
Aldrin	309-00-2	Endrin aldehyde	7421-93-4
alpha-BHC	319-84-6	gamma-BHC	58-89-9
alpha-Chlordane	5103-71-9	gamma-Chlordane	5103-74-2
alpha-Endosulfan	959-98-8	Heptachlor	76-44-8
beta-BHC	319-85-7	Heptachlor expoxide	1024-57-3
beta-Endosulfan	33213-65-9	Methoxychlor	72-43-5
Chlordane	5103-71-9	Mirex	2385-85-5
delta-BHC	319-86-8	Toxaphene	8001-35-2

4.9. OP Pesticides (EPA 8140/8141; µg/kg for particle results, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Azinphos methyl	86-50-0	Merphos	150-50-5
Bolstar (Sulprofos)	35400-43-2	Methidathion	950-37-8
Chlorpyrifos	2921-88-2	Methyl trithion	953-17-3
Coumaphos	56-72-4	Mevinphos	7786-34-7
Def	78-48-8	Naled	300-76-5
Demeton-O	298-03-3	Parathion, ethyl	56-38-2
Demeton-S	126-75-0	Parathion, methyl	298-00-0
Demeton-O and S	CT-DEMETON-O-S	Phorate	298-02-5
Diazinon	333-41-5	Phosalone	2310-17-0
Dichlorvos	62-73-7	Phosmet	732-11-6
Dimethoate	60-51-5	Prometon	1610-18-0
Diphenamid	957-51-7	Prowl	40487-42-1
Disulfoton	298-04-4	Ronnel	299-84-3
Ethion	563-12-2	Simazine	122-34-9
Ethoprop	13194-48-4	Stirophos (Tetrachlorvinphos)	22248-79-9
Fensulfothion	115-90-2	Tokuthion (Prothiofos)	34643-46-4
Fenthion	55-38-9	Trichloronate	327-98-0
Malathion	121-75-5	Trifluralin	1582-09-8

4.10. Other Pesticides (EPA 8150; µg/kg for particle results, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
2,4,5-T	93-76-5	Dicamba	1918-00-9
2,4,5-TP (Silvex)	93-72-1	Dichlorprop	120-36-5
2,4-D	94-75-7	Dinoseb (DNBP)	88-85-7
2,4-DB	94-82-6	MCPA	94-74-6
Dalapon	75-99-0	MCPP	93-65-2

4.11. Miscellaneous Pesticides (µg/kg for particle results, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Alachlor	15972-60-8	Metolachlor	51218-45-2
Atrazine	1912-24-9	Molinate	2212-67-1
Bromacil	314-40-9	Oryzalin	19044-88-3
Cacodylic acid	75-60-5	Oxadiazon	19666-30-9
Chlorsulfuron	64902-72-3	Oxamyl	23135-22-0
Cyanazine	21725-46-2	Oxyfluorfen	42874-03-3
Diquat	85-00-7	Paraquat	4685-14-7
Diuron	330-54-1	Prometryn	7287-19-6
Fluazifop-p-butyl	69806-50-4	Sulfometuron-methyl	74222-97-2
Glyphosate	1071-83-6	Thiobencarb	28249-77-6
Isoxaben	82558-50-7	Triclopyr	55335-06-3
Mefluidide	53780-34-0		

4.12. Polychlorinated Biphenyls – PCBs (µg/kg for particle results, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Arochlor 1016	12674-11-2	Arochlor 1248	12672-29-6
Arochlor 1221	11104-28-2	Arochlor 1254	11097-61-1
Arochlor 1232	11141-16-5	Arochlor 1260	11096-82-5
Arochlor 1242	53469-21-9	PCBs (total)	CT-TPCB

4.13. Hydrocarbons (mg/kg for particle/sediment results, typically)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID #
Oil & Grease	CT-OILGREASE	TPH (Kerosene)	CT-KEROSENE
TEPH	CT-TEPH	TPH (Motor Oil)	CT-MOIL
TPH (Diesel)	68334-30-5	TPH (Stoddard Solvent)	CT-STODSOL
TPH (Gasoline)	8006-61-9	TRPH	CT-TRPH
TPH (Heavy Oil)	CT-HOIL	TVPH	CT-TVPH
TPH (Jet Fuel)	CT-JETFUEL		

4.14. Miscellaneous Constituents (ug/L, typically – unless noted)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID
2,3,7,8-Tetrachloro-dibenzo-p-dioxin	1746-01-6	Cyanide (mg/L)	57-12-5

4.15. Sample Physical Parameters (expressed in various units as noted)

Constituent	CAS or Caltrans ID #	Constituent	CAS or Caltrans ID
Dry Density (pcf)	CT-DRYDEN	Gravel Content (% of sample)	CT-%GRAVEL
Mass (g)	CT-MASS	Particle Count Fraction (#/L)	CT-PCF
Particle Size Fraction (%)	CT-PSF	Relative % Compaction (%)	CT-RPC
Clay Content (% of sample)	CT-%CLAY	Sand Content (% of sample)	CT-%SAND
Silt Content (% of sample)	CT-%SILT		
Silt/Clay Content (% of sample)	CT-%SILTCLAY		

5. MEASURING UNITS CONVERSION TABLES

5.1. Length Conversions

Metric	Converting to >	Imperial
1 millimeter (mm)		0.0394 in
1 centimeter (cm)	10 mm	0.3937 in
1 meter (m)	100 cm	3.2808 ft
1 meter (m)	100 cm	1.0936 yd
1 kilometer (km)	1,000 m	0.6214 mile

Imperial	Converting to >	Metric
1 inch (in)		25.40 mm
1 inch (in)		2.54 cm
1 foot (ft)	12 in	0.3048 m
1 yard (yd)	3 ft	0.9144 m
1 mile	1,760 yd	1.6093 km

5.2. Area Conversions

Metric	Converting to >	Imperial
1 square cm (cm^2)	100 mm^2	0.1550 in^2
1 square m (m^2)	10,000 cm^2	1.1960 yd^2
1 hectare (ha)	10,000 m^2	2.4711 acres
1 square km (km^2)	100 ha	0.3861 $mile^2$

Imperial	Converting to >	Metric
1 square inch (in^2)		6.4519 cm^2
1 square foot (ft^2)	144 in^2	0.0929 m^2
1 square yard (yd^2)	9 ft^2	0.8361 m^2
1 acre	4840 yd^2	4046.9 m^2
1 acre	4840 yd^2	0.4047 ha
1 square mile ($mile^2$)	640 acres	2.59 km^2

5.3. Volume/Capacity Conversions

Metric	Converting to >	Imperial
1 cubic cm (cm^3)		0.0610 in^3
1 cubic decimeter (dm^3)	1,000 cm^3	0.0353 ft^3
1 cubic meter (m^3)	1,000 dm^3	1.3080 yd^3
1 liter (L)	1 dm^3	1.76 pt
1 hectoliter (hL)	100 L	21.997 gal

Imperial	Converting to >	Metric
1 cubic inch (in^3)		16.387 cm^3
1 cubic foot (ft^3)	1,728 in^3	0.0283 m^3
1 fluid ounce (fl oz)		29.5735 mL
1 pint (pt)	16 fl oz	0.4732 L
1 gallon (gal)	8 pt	3.785 L

5.4. Mass Conversions

Metric	Converting to >	Imperial
1 milligram (mg)		0.0154 grain
1 gram (g)	1,000 mg	0.0353 oz
1 kilogram (kg)	1,000 g	2.2046 lb
1 metric ton (t)	1,000 kg	2,204.6 lb

Imperial	Converting to >	Metric
1 ounce (oz)	437.5 grain	28.35 g
1 pound (lb)	16 oz	0.4536 kg
1 short ton (US)	2,000 lb	0.907 t

SECTION 2.3

Caltrans Data Reporting Protocols: Gross Solids

NOVEMBER 2003

Caltrans Monitoring and
Water Quality Research Program

2003-2004 Gross Solids Data Reporting Protocols

CTSW-RT-03-100.51.42

Prepared for:
California Department of Transportation
Environmental Program

GENERAL INSTRUCTIONS

Please read and be familiar with these general instructions. Gross solids data can only be accurately and expediently incorporated into the Caltrans Master Stormwater Database if these instructions are carefully followed. Adhering to these instructions will facilitate the processing of data and eliminate the need for time-consuming "record-by-record" data validation at year's end.

- **Get Monitoring Site IDs from Caltrans at the beginning of each monitoring season.**

  Caltrans will assign the "Monitoring Site ID" for all monitoring sites. All Caltrans data reporters are required to contact the Caltrans database manager (Mike Trouchon – Larry Walker Associates) at the **beginning** of each sampling season to receive Monitoring Site IDs for each new site they will sample. Note that BMP sites having multiple points of collection (e.g., inlet, within, outlet, bypass, overflow, etc.) will be assigned a unique Monitoring Site ID for each point of collection. Data reporters shall provide the database manager with the names of each site, the type of monitoring to be performed, and the Caltrans district in which each site resides.

- **Enter data appropriately.**

  To facilitate the accurate entry of gross solids data into Excel worksheets or Access data tables by Caltrans data reporters, and the subsequent transfer of this data into the Caltrans Master Stormwater Database, each data field described in this data-reporting protocol document possesses the following attributes: Field Name, Field Type, Field Size, Example, Definition, Notes (where applicable), Standard List (where applicable) and Alternate Value (where applicable). These eight data field attributes are defined below.

Field Name	Name of data field as it appears in the Excel worksheet or Access data table used for data reporting.
Field Type	Specifies the type of data, text or numeric that can be stored in a field. Note: text fields can store both text and numbers.
Field Size	Specifies the number of characters that can be stored in a text field or the number of decimal places required of a number entered into a numeric field.
Example	Provides an example of the data type and possible value that is appropriate for a specific data field.
Definition	Provides a definition of the data type and possible value that is appropriate for a specific data field.
Notes	Provides further information that may be helpful in appropriately and accurately populating a specific data field.
Standard List	Provides a list of standard values appropriate for populating a specific data field.
Alternate Value	Specifies if the use of "N/A" (not applicable) or "None" is an appropriate value for a specific data field.

GENERAL INSTRUCTIONS (CONTINUED)

Additionally, the following rules should be abided by when entering gross solids data into either Excel worksheets or Access data tables.

- **Select and enter text values only from the "Standard List"** of values provided for each data field. Standardized values must be entered exactly as specified. Standard lists are included with the description of each data field where appropriate. If a standardized value provided for a particular data field does not accurately describe the data to be entered into that field, please contact the Caltrans database manager to discuss the creation of an additional value for a particular data field.

- **Use "Constituent" names exactly as they appear in the standardized constituent list, and report data in the appropriate Result Type and Units as specified in these protocols.**

- **Enter numeric data values according to the definition provided for the particular numeric data field.** Text must not be entered into numeric data fields. Text-based comments regarding a numeric value should be placed in the "Notes" data field.

- **"Mobilization ID" follows the format YYYY-Some combination of text and/or numbers** ("Year monitoring season begins-Unique string of text and/or numbers that signify to the data provider a specific storm or gross solids sampling event that occurred at a particular monitoring site"). Mobilization IDs for the 2003-2004 Caltrans monitoring season would all begin with "2003".

- **Use the correct system for date entries when using Microsoft Excel.** Dates must be entered using the Excel "1900 Date System" typical for Windows (the "1900 Date System" is the default date system used by Microsoft Excel installed on computers running a Windows operating system). The "Macintosh 1904 Date System" should be switched off in Excel preferences (located in the following nested menus: Tools >> Options >> Calculation). Data providers managing their data exclusively in Microsoft Access need not address this issue.

- **Values contained in data fields that link records from one Excel worksheet or Access table to another, such as Monitoring Site ID and Mobilization ID, must match exactly** for the correct relationship to exist between records once the data is imported into the Caltrans Master Stormwater Database (Version 2.0 built using Microsoft Access 2000). No match can be made between a Monitoring Site ID of "7 –144" (note an extra space between the 7 and the hyphen) found in the Gross Solids Site Descriptions worksheet or data table and a Monitoring Site ID of "7-144" found in the Gross Solids Sample Descriptions worksheet or data table. In general, wherever data field entries are hyphenated, do not include spaces.

- **If any cell in a data field is left blank* (i.e., the data cell is null), a brief note explaining why the data cell was left blank must accompany the particular record.** The brief note shall be placed in the "Notes" data field associated with the particular record containing one or more blank data cells.

  *Exception – The following data field can contain null values without an associated note entered in the "Notes" data field of the relevant worksheet or data table:

Excel Worksheet or Access Table	Data Field
Gross Solids Sample Descriptions	Overall Qualifier
" "	Gross Solids Photo ID

- **The use of "N/A" as a value entered into a text data field is acceptable for some fields** where the data field definition does not apply to the particular data record being entered. For example, the data field "Gross Solids Type" (found in the Gross Solids Sample Descriptions worksheet) applies only to "special project" Caltrans gross solids monitoring studies that categorized the different types of gross solids collected (e.g., plastic, wood, paper, metal, etc.). This data field is "not applicable" to routine gross solids monitoring that does not categorize the gross solids collected. Data fields where the use of "N/A" is acceptable have this data value option specified in the Alternate Value attribute. "N/A" cannot be entered into a numeric data field. ***Additionally, the use of the value "Other" is nor acceptable for any data field.***

- **Make sure that all required data records for a particular sampling event exist in the Gross Solids Sample Descriptions, Gross Solids Sampling Event Descriptions and Gross Solids Site Descriptions worksheets or data tables according to the following rules used to maintain referential integrity among all related records:**

  - A Monitoring Site ID value (e.g., 7-144) contained in the Gross Solids Sample Descriptions worksheet or data table must be represented by a single record for the same Monitoring Site ID in the Gross Solids Site Descriptions worksheet or data table.

  - A Monitoring Site ID value (e.g., 7-144) contained in the Gross Solids Site Descriptions worksheet or data table must be represented by at least one record in the Gross Solids Sample Descriptions worksheet or data table.

  - A unique combination of Monitoring Site ID (e.g., 7-144) and Mobilization ID (e.g., 2003-01) contained in the Gross Solids Sample Descriptions worksheet or data table must be represented by a single record for the same unique Monitoring Site ID/Mobilization ID pair in the Gross Solids Sampling Event Descriptions worksheet or data table. Do not forget to create an Event Descriptions record for "non-storm" monitoring events (such as dry season, mid-season, or end-of-season gross solids sampling) even though these events may not include the collection of precipitation and runoff data (the data fields Mobilization ID, Site ID, Event Type, Sample Collector, Organization and Event Notes can be populated for these non-storm event records).

  - A unique combination of Monitoring Site ID (e.g., 7-144) and Mobilization ID (e.g., 2003-01) found in the Gross Solids Sample Event Descriptions worksheet or data table must be represented by at least one record in the Gross Solids Sample Descriptions worksheet or data table having the same Monitoring Site ID/Mobilization ID pair.

- **<u>Do not report analytical results for field duplicates or other QA/QC samples.</u> Report only values from environmental samples that have been QA/QC'ed.**

- **Submit Caltrans data exactly in the format specified by these data-reporting protocols.**

  All Caltrans "Electronic Data Deliverables" (EDD) must be submitted in the format described in this document. All Excel worksheets or Access data tables submitted by data providers must be formatted according to the requirements of the data fields contained within them as described in this data-reporting protocols document. All data field headings should remain as they are described in this document. Before submitting EDD to the database manager, please confirm that all data entered in either a column (for Excel worksheets) or data field (for Access data tables) are appropriate for that particular field.

- **If a sample is analyzed and subsequently deemed not to be representative of the monitoring event from which it was collected, then the data should not be included as part of the data reporter's EDD.**

  Furthermore, if individual records or complete monitoring events are deemed invalid or unrepresentative at the end of the monitoring season, and hence excluded from analysis and discussion in a contractor's final monitoring report, then the Caltrans database manager (Mike Trouchon – Larry Walker Associates) must be notified to remove these same invalid or unrepresentative data from the Caltrans Master Stormwater Database.

- **Label all elements of each Electronic Data Deliverable (EDD) clearly**

  - The Excel workbook file or Access database file containing Gross Solids Sample Descriptions, Gross Solids Sampling Event Descriptions and Gross Solids Site Descriptions data should be labeled with the name of the data reporter (consultant or university), the title of the Caltrans activity under which the data were collected, and the monitoring season (e.g., 2003-2004 or 03-04) during which the data were collected.

    File naming convention for gross solids data:

Gross solids data file	URS LIDS Gross Solids Data_2003-2004
	UCLA FFCS Gross Solids Data_2003-2004

  - The submittal of supporting data and documents, such as time series data, maps and photographs, should be labeled with the Caltrans Monitoring Site ID and monitoring season to which they correspond. Time series data collected during storm events at a monitoring site can be submitted as multiple worksheets (one worksheet for each storm event monitored) in a single Excel workbook that represents all time series data collected at that site during an entire monitoring season.

    File naming conventions for supporting data:

Time Series file	Site 7-144 Time Series_2003-2004.xls
Map file	Site 7-144 Map_2003-2004.pdf
Photograph file	Site 7-144 Photo_2003-2004.jpeg

- When submitting an EDD to the Caltrans database manager, please compile all files (gross solids data, including sample, event and site descriptions, time series data (if collected), maps and photographs) onto one or more recordable compact discs (CD-R) labeled with the data reporter's name and date of data submittal. Mail CD(s) to the database manager at the address provided below.

- **Please notify Caltrans of any errors or inconsistencies found in this document, or any changes you might recommend.**

Definition of a Precipitation Event

Storm event criteria to be met for the mobilization and subsequent collection of gross solids monitoring data will be included in future drafts of this document. Consultants are advised to follow mobilization and sampling protocols described in the individual sampling plans associated with the gross solids monitoring studies they manage.

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1. GROSS SOLIDS SAMPLE DESCRIPTIONS

1.1. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-144
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located. Monitoring sites in a given Caltrans District numbered between 1 and 9 must be reported with a 0 (zero) in their Monitoring Site IDs (e.g., 7-09, as opposed to 7-9).

1.2. Outfall ID

Field Type: Text
Field Size: 20 characters
Example: 6-20F
Definition: A unique name or number assigned to the gross solids monitoring site by the contractor.
Notes: Each Monitoring Site ID must correspond to only one Outfall ID and vice versa. Since Outfall ID is an internal identification label used by a contractor, and is typically not used by the database manager and Caltrans when referring to gross solids monitoring sites, contractors are reminded to make sure that all gross solids records include a reference to an official Caltrans Monitoring Site ID.

1.3. Drainage System Component

Field Type: Text
Field Size: 35 characters
Example: Outfall Bag
Definition: Describes the drainage system component from where the reported gross solids sample was removed.
Notes: Standardized Entry. Select value from standard list or contact database manager. Depending on the gross solids removal device (GSRD) employed, unique drainage system component values <u>not</u> listed below may need to be used by a contractor to accurately describe the drain system components associated with the GSRD located at a particular monitoring site.

<u>Standard List</u>

- Bypass Bag
- Cage
- Drain Inlet
- GSRD Contents
- Inlet
- Outfall Bag
- Outfall Pipe
- Overflow Weir

1.4. Mobilization ID

Field Type: Text
Field Size: 20 characters
Example: 2003-01
Definition: A unique, site-specific identification code assigned to the mobilization effort for a particular sampling event that occurred at a particular monitoring site.
Notes: Mobilization ID follows the format YYYY-Some combination of text and/or numbers ("Year monitoring season begins-Unique string of text and/or numbers that signify to the data provider a specific storm or gross solids sampling event that occurred at a particular monitoring site"). Even if a site isn't monitored until the latter half of the monitoring season (e.g., Site X is monitored during Feb. – Apr. 2004 – the latter half of the 2003-2004 monitoring season), its Mobilization IDs include the year in which the general Caltrans monitoring season began (i.e., Mobilization IDs for samples collected at Site X would all begin with "2003").

1.5. Sample Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which gross solids sample was collected (i.e., date as recorded on chain of custody or sample label).
Notes: Formatted as mm/dd/yyyy.

1.6. Sample Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which gross solids sample was collected (i.e., time as recorded on chain of custody or sample label).
Notes: Formatted for 24-hour clock (hh:mm).

1.7. Activity

Field Type: Text
Field Size: 50
Example: pre-event collection
Definition: Describes the type of monitoring activity performed by the consultant while visiting the monitoring site. The Activity value assigned to a sample record also describes the point during an individual event or an entire monitoring season at which the gross solids sample was collected.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Pre-event collection
- Mid-event collection
- Post-event collection
- Pre-season collection
- Mid-season collection
- End-of-season collection
- Dry season monitoring
- Cleanout (extra collection)
- Final cage cleanout
- Final inlet cleanout
- Final outfall cleanout

1.8. Event Representation

Field Type: Text
Field Size: 20 characters
Example: FF
Definition: Describes the part of the event represented by the sample.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Pre-Storm - Sample collected prior to storm event
- FF - Sample collected during event first flush
- Peak - Sample collected during event peak flow
- Whole - Sample collected at the end of a storm event
- Discrete - Sample collected during an event that cannot be described as representing the first flush, peak or whole storm portion of the event.
- Partial Season - Sample collected at some point during the monitoring season
- Whole Season - Sample collected at the end of the monitoring season

1.9. Sample Matrix

Field Type: Text
Field Size: 12 characters
Example: Gross Solids
Definition: Matrix from which sample was analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Gross Solids

1.10. Wet Dry

Field Type: Text
Field Size: 1 character
Example: W
Definition: Describes gross solids sample as being either wet or air-dried at the time it was analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- W - Gross solids sample was wet when analyzed
- D - Gross solids sample was air-dried when analyzed

1.11. Constituent

Field Type: Text
Field Size: 10 characters
Example: GS
Definition: Describes the general type of gross solids analyzed.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- GS - Gross Solids
- Veg - Vegetation
- Lit - Litter
- Bio Lit - Biodegradable Litter
- Nonbio Lit - Non-biodegradable Litter
- NF Lit - Non-floatable Litter

1.12. Litter Type

Field Type: Text
Field Size: 25 characters
Example: Paper
Definition: Describes the category of litter to which individual litter sample constituents belong.
Notes: Standardized Entry. Select value from standard list or contact database manager. This data field is used to describe the individual litter constituents found in a gross solids sample collected as part of a Caltrans gross solids monitoring study (i.e., "special project studies") that categorizes the different types of litter contained in a sample. "Litter" data records having **Constituent values equal to Lit, Bio Lit, Nonbio Lit, and NF Lit** from routine gross solids sampling studies where individual litter constituents within a sample are not further characterized by Litter Type will have this data field populated with the alternate value, "Total". Additionally, gross solids data records having **Constituent values of GS and Veg** will have the Litter Type data field populated with the alternate value, "N/A".

Standard List

- Cardboard/Chipboard
- Cigarette Butts
- Cloth
- Glass
- Metal (Foil and Molded)
- Other
- Paper
- Plastic-Film
- Plastic-Moldable
- Styrofoam
- Wood

Alternate Values: - Total (see Notes above).
- N/A (see Notes above).

1.13. Numerical Qualifier

Field Type: Text
Field Size: 1 character
Example: <
Definition: An indication of what the Reported Value for an analyzed sample represents (i.e., a minimum, maximum or "exact" value).
Notes: Standardized Entry. Select value from standard list or contact database manager. Please refer to Overall Qualifier (see data field 1.15 below) for additional guidance on the appropriate qualification of gross solids results.

Standard List

- < - Actual value of analyzed sample is less than reported value. This symbol must be used for all "non-detect" samples.
- = - Value of analyzed sample is as reported.
- > - Actual value of analyzed sample is greater than reported value.

1.14. Reported Value

Field Type: Numeric
Field Size: N/A
Example: 0.25
Definition: Reported laboratory result of analyzed sample.
Notes: Precision of Reported Values – As described in the Caltrans Gross Solids Monitoring Guidance Manual, weight and volume measurements must be reported according to the following directives:

Report weight to the nearest 1 g.

Report volume according to the sample size, as follows:

- Samples from 10 mL ≤ 1 L report to the nearest 10 mL (example: 760 mL)
- Samples from 1 L ≤ 10 L report to the nearest 100 mL (example: 9700 mL)
- Samples greater than 10 L report to the nearest 1 L (example: 15000 mL)

1.15. Overall Qualifier

Field Type: Text
Field Size: 1 character
Example: J
Definition: An overall data validation qualifier based on lab results and associated quality assurance/quality control (QAQC) analyses.
Notes: Standardized Entry. Select value from standard list or contact database manager. The qualifiers and definitions presented below represent a compilation of data qualifiers used by specific EPA programs as noted in: (1) *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 1994); and (2) *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999).

Standard List

- J - The associated value is approximate (i.e., an estimated quantity).
- R - The sample result is rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria.

1.16. Result Type

Field Type: Text
Field Size: 15 characters
Example: volume
Definition: Describes the type of measurement (sum, volume, weight) associated with the Reported Value.
Notes: Standardized Entry. Select value from standard list or contact database manager. Only data records from Caltrans gross solids monitoring studies that categorize the different types of litter collected will possess Result Type values equal to "% total count", "% total volume", and "% total weight".

Standard List

- sum - Result type associated with the unit "count"
- volume - Result type associated with the unit "mL"
- weight - Result type associated with the unit "g"
- % total count - Result type associated with the unit "percent"
- % total volume - Result type associated with the unit "percent"
- % total weight - Result type associated with the unit "percent"

1.17. Units

Field Type: Text
Field Size: 8 characters
Example: mL
Definition: Describes the unit of measure associated with the Reported Value.
Notes: Standardized Entry. Select value from standard list or contact database manager. Use capital "L" for liter abbreviation.

Standard List

- count
- g
- mL
- percent

1.18. Method Reference

Field Type: Text
Field Size: 12 characters
Example: EPA
Definition: Provides the reference for the analytical method used to evaluate the sample.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Caltrans - Caltrans-defined analytical method
- LMPS Method - Method developed specifically for the Caltrans Litter Management Pilot Study

1.19. Method Number

Field Type: Text
Field Size: 10 characters
Example: 1998A
Definition: Reference number for the analytical method used to evaluate the sample. This number typically references the year the method was developed for the study.
Notes: By convention, method numbers that contain a text suffix do not include a space between the number and the text suffix (e.g., 1998A).

1.20. Project Name

Field Type: Text
Field Size: 6 characters
Example: LMPS
Definition: Name of Caltrans stormwater monitoring study under which gross solids sample was collected.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- DICE - Drain Inlet Cleaning Efficiency Study
- FFCS - First Flush Characterization Study
- GSRD - Gross Solids Removal Device Study
- LIDS - Litter Inlet Deflector Study
- LMPS - Litter Management Pilot Study
- PELMS - Public Education Litter Monitoring Study

1.21. Consultant

Field Type: Text
Field Size: 8
Example: URS
Definition: Name of consultant that collected gross solids sample (same name as appears on chain of custody form).
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- URS
- CDM
- UCLA
- BMC

1.22. Lab Name

Field Type: Text
Field Size: 10 characters
Example: APPL
Definition: Name of laboratory that analyzed gross solids sample.
Notes: Standardized Entry. Select value from standard list or contact database manager. If the name of a laboratory used to analyze samples does not appear in the list below, simply report the name of the laboratory in this data field. The database manager will notice the new laboratory name during routine data validation and will add it to the Standard List below in a subsequent version of this document.

Standard List

- SNA - Santa Ana
- FSO - Fresno
- DV - Dellevalle

1.23. Gross Solids Photo ID

Field Type: Text
Field Size: 50 characters
Example: PA300006
Definition: Identification number of photograph associated with air-dried gross solids sample collected from a particular gross solids monitoring site on a particular date. If no photograph was taken of a particular gross solids sample, it is acceptable to report this data field value as the Alternate Value of "None".
Notes: This data field can contain any combination of text and numeric characters. However, it might prove useful for consultant to include the Monitoring Site ID (e.g., 10-201) or Outfall ID (e.g., I5-PE9) and the Sample Date (e.g., 12/14/02) associated with the photograph as part of the string of characters that comprise the Gross Solids Photo ID (alternate example: I5-PE9_121402_GSPhoto02).

Alternate Value: - None (see Definition above).

1.24. Contract Number

Field Type: Text
Field Size: 12 characters
Example: 43A005
Definition: Caltrans contract number under which sample was collected.
Notes: This data field can contain any combination of text and numeric characters.

1.25. Task Order Number

Field Type: Text
Field Size: 6 characters
Example: 11
Definition: Caltrans task order number under which sample was collected.
Notes: This data field can contain any combination of text and numeric characters.

1.26. Gross Solids Sample Notes

Field Type:	Text
Field Size:	255 characters
Example:	Sample Time missing due to time being omitted from field data sheet.
Definition:	This data field contains any notes or remarks about the sample or various data fields used to describe the sample.
Notes:	Data reporter should provide a note for any data field left blank (with the exception of Overall Qualifier). It is not appropriate to provide a note in a particular cell of a data field other than Gross Solids Sample Notes. Considering the example above, it is not appropriate to place the note, "Sample Time missing due to time being omitted from field data sheet", in the Sample Time data field. The note must be entered into the Gross Solids Sample Notes data field.

2. GROSS SOLIDS SAMPLING EVENT DESCRIPTIONS

2.1. Mobilization ID

Field Type: Text
Field Size: 20 characters
Example: 2003-01
Definition: A unique, site-specific identification code assigned to the mobilization effort for a particular sampling event that occurred at a particular monitoring site.
Notes: Mobilization ID follows the format YYYY-Some combination of text and/or numbers ("Year monitoring season begins-Unique string of text and/or numbers that signify to the data provider a specific storm or gross solids sampling event that occurred at a particular monitoring site"). Even if a site isn't monitored until the latter half of the monitoring season (e.g., Site X is monitored during Feb. – Apr. 2004 – the latter half of the 2003-2004 monitoring season), its Mobilization IDs include the year in which the general Caltrans monitoring season began (i.e., Mobilization IDs for samples collected at Site X would all begin with "2003").

2.2. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-144
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located. Monitoring sites in a given Caltrans District numbered between 1 and 0 must be reported with a 0 (zero) in their Monitoring Site IDs (e.g., 7-09, as opposed to 7-9).

2.3. Event Type

Field Type: Text
Field Size: 10 characters
Example: Non-storm
Definition: Describes if sampling event is associated with a storm event or a non-storm event.
Notes: Standardized Entry. Select value from standard list or contact database manager. This data field quickly describes whether an event record includes precipitation and flow data (i.e., event is a storm event) or does not necessarily include such precipitation and flow data (i.e., event is a non-storm event, such as a dry weather or groundwater sampling event; note: flow data could be provided for a dry weather event). Storm event records that are missing various precipitation and flow data due to malfunctioning equipment must be described with Event Type equal to "Storm" and include remarks in their Event Notes data field as to why certain data are missing.

<u>Standard List</u>

- Storm
- Non-storm

2.4. Rain Start Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which precipitation event begins. See specific gross solids sampling plan to determine criteria that define a precipitation event for a particular monitoring study.
Notes: Formatted as mm/dd/yyyy.

2.5. Rain Start Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which precipitation event begins. See specific gross solids sampling plan to determine criteria that define a precipitation event for a particular monitoring study.
Notes: Formatted for 24-hour clock (hh:mm).

2.6. Rain End Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which precipitation event ends. See specific gross solids sampling plan to determine criteria that define a precipitation event for a particular monitoring study.
Notes: Formatted as mm/dd/yyyy.

2.7. Rain End Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which precipitation event ends. See specific gross solids sampling plan to determine criteria that define a precipitation event for a particular monitoring study.
Notes: Formatted for 24-hour clock (hh:mm).

2.8. Event Rain (mm)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 15.99
Definition: Total rain at site for an event in millimeters (mm).
Notes: The Site Descriptions data field named Rain Record Source identifies the source of the Event Rain data for a particular monitoring site. See specific gross solids sampling plan to determine criteria that define a precipitation event for a particular monitoring study.

2.9. Max Intensity (mm/hr)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 12.18
Definition: Peak 5-minute intensity of a storm event in millimeters/hour (mm/hr).
Notes: Maximum Intensity is calculated as twelve times (12 x) the maximum rainfall recorded in any 5-minute period.

2.10. Antecedent Dry (days)

Field Type: Numeric
Field Size: Provide number only to one (1) decimal place.
Example: 12.0
Definition: Days since the end of the most recent prior Caltrans-defined precipitation event (whether monitored or not). If datum exists, irrespective of whether the prior event was monitored, data reporter should include Antecedent Dry datum as part of the Event Record for the current event.
Notes: See specific gross solids sampling plan to determine criteria that define a precipitation event for a particular monitoring study. With reference to the first precipitation event monitored at a particular monitoring site, it might be necessary to look back in time before the start of the current monitoring season (typically Oct. 1st) to identify the last precipitation event that occurred at said site. If data exist for a precipitation event that occurred during June through September (i.e., occurred between the current and previous monitoring season), then these data should be used when calculating the Antecedent Dry value for the first precipitation event monitored during the current monitoring season.

2.11. Antecedent Event Rain (mm)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 24.37
Definition: Total rain at site for the most recent antecedent Caltrans-defined precipitation event in millimeters (mm). The antecedent precipitation event used for this data field should be the <u>same</u> antecedent precipitation event referenced in the Antecedent Dry data field. The quantification of Antecedent Event Rain does <u>not</u> include "inter-event" precipitation.
Notes: Using the examples provided above for Antecedent Dry and Antecedent Event Rain, the antecedent or prior precipitation event for Site X occurred 12.0 days ago, and delivered 24.37 mm of rainfall. The antecedent precipitation event must meet Caltrans' criteria for a precipitation event. See specific gross solids sampling plan to determine criteria that define a precipitation event for a particular monitoring study. With reference to the first precipitation event monitored at a particular monitoring site, it might be necessary to look back in time before the start of the current monitoring season (typically Oct. 1st) to identify the last precipitation event that occurred at said site. If data exist for a precipitation event that occurred during June through September (i.e., occurred between the current and previous monitoring season), then these data should be used when calculating the Antecedent Event Rain value for the first precipitation event monitored during the current monitoring season.

2.12. Peak Capture

Field Type: Text
Field Size: 1 character
Example: Y
Definition: Indication of whether peak flow was captured during sampling event.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Y - Yes, peak flow was captured.
- N - No, peak flow was not captured.

2.13. Runoff Start Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which first runoff begins.
Notes: Formatted as mm/dd/yyyy.

2.14. Runoff Start Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which first runoff begins.
Notes: Formatted for 24-hour clock (hh:mm).

2.15. Runoff End Date

Field Type: Date
Field Size: N/A
Example: 11/05/2003
Definition: Date on which last runoff ceases.
Notes: Formatted as mm/dd/yyyy.

2.16. Runoff End Time

Field Type: Time
Field Size: N/A
Example: 15:24
Definition: Time at which last runoff ceases.
Notes: Formatted for 24-hour clock (hh:mm)

2.17. Total Flow Volume (L)

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 38686
Definition: Total measured flow volume in liters (L) at a monitoring site for an event.

2.18. Peak Flow (L/s)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 3.40
Definition: Estimated peak flow of runoff in liters per second (L/s) at a monitoring site for an event.

2.19. Estimated Percent Capture

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 99
Definition: Estimated percentage of total event flow volume during which monitoring was performed (i.e., while the sampler was activated and flow-proportioned sample collection was successfully occurring). Report datum only if estimate is based on actual runoff and sample collection data measured by an instrument located at the monitoring site in question.
Notes: Periods of sampler malfunction or failure to collect sample must be excluded from the "captured flow".

2.20. Cumulative Precipitation (mm)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 100.76
Definition: Estimated cumulative precipitation in millimeters (mm) at monitoring site since the beginning of the water year (October 1), up to the Rain Start Date/Time for the monitored event. All precipitation that has fallen to date at a site, including "inter-event" precipitation, should be included in the Cumulative Precipitation value reported for that site for a particular event.

2.21. Sample Collector

Field Type: Text
Field Size: 25 characters
Example: Roy Estrada
Definition: Name of the individual who collected the sample.

2.22. Organization

Field Type: Text
Field Size: 30 characters
Example: Acme Environmental
Definition: Organization to which the sample collector is associated.

2.23. Event Notes

Field Type:	Text
Field Size:	255 characters
Example:	Runoff End Time missing due to malfunctioning flow meter.
Definition:	This data field contains any notes or remarks about the sampling event or various data fields used to describe the sampling event.
Notes:	Data reporter should provide a note for any data field left blank. It is not appropriate to provide a note in a particular cell of a data field other than Event Notes. Considering the example above, it is not appropriate to place the note, "Runoff End Time missing due to malfunctioning flow meter", in the Runoff End Time data field. The note must be entered into the Event Notes data field.

3. GROSS SOLIDS SITE DESCRIPTIONS

3.1. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-144
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located. Monitoring sites in a given Caltrans District numbered between 1 and 9 must be reported with a 0 (zero) in their Monitoring Site IDs (e.g., 7-09, as opposed to 7-9).

3.2. Monitoring Year

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 2003
Definition: Identifies the monitoring season a site is monitored by populating the data field with the year the current monitoring season begins.
Notes: In regard to the 2003-2004 monitoring season, the Monitoring Year value for each site monitored would be "2003" – the year the current monitoring season began. The term Monitoring Year refers to only a single calendar year, while the term Monitoring Season necessarily refers to two calendar years, such as 2003-2004.

3.3. Site Name

Field Type: Text
Field Size: 100 characters
Example: 6-20F
Definition: A unique name or number assigned to the gross solids monitoring site by the consultant.
Notes: Site Name is meant to be a shorthand designation for the monitoring site, and the "common name" by which the sampling crew and data reporter refer to the site.

3.4. Site Description

Field Type: Text
Field Size: 255 characters
Example: East of Ocean View Avenue Onramp to EB 210 Fwy; a low-density residential site within foothills.
Definition: Describes monitoring site in some detail, including observations related to site's location and physical characteristics.
Notes: In addition to the above definition, this field can be used to describe changes observed at the site since the prior monitoring season.

3.5. Caltrans District

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 7
Definition: Caltrans district in which monitoring site is located.

3.6. Hydrologic Sub-Area

Field Type: Numeric
Field Size: Provide 5-digit number in the format XXX.XX
Example: 405.32
Definition: State Water Resources Control Board (SWRCB) Hydrologic Unit Sub-Area in which monitoring site is located.
Notes: SWRCB Hydrologic codes are 6-byte strings composed of numbers and a decimal point. The meaning associated with each byte position is shown below.

Byte(s)	Meaning
1	Hydrologic Region
2,3	Hydrologic Unit
4	Decimal point
5	Hydrologic Area
6	Hydrologic Sub-Area

Hydrologic sub-areas are typically identified in Basin Plans. They may also be found at the Water Quality Standards Inventory Database web site: http://endeavor.des.ucdavis.edu/wqsid/region.asp

3.7. County

Field Type: Text
Field Size: 25 characters
Example: Los Angeles
Definition: County in which monitoring site is located.
Notes: It is not necessary to include the word "County" along with the actual name of the county in which the monitoring site is located.

3.8. RWQCB

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 4
Definition: Regional Water Quality Control Board (RWQCB) region in which monitoring site is located.

3.9. Runoff Characterization

Field Type: Text
Field Size: 20 characters
Example: Hwy
Definition: Type of runoff characterized by samples collected from monitoring site.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Hwy - Highway or Freeway
- Maintenance - Maintenance facility
- Parking - Parking lot (e.g., Park & Ride facility)
- Rest Area - Rest area
- Acceleration - Acceleration area
- Deceleration - Deceleration area
- Construction - Construction
- BMP - Site designed for storm water treatment
- Border Check-point - Border Check-point
- Bridge - Bridge
- CVIF - Commercial Vehicle Inspection Facility
- Receiving - Receiving water (described further in "Receiving Water Type)
- Toll Plaza - Toll Plaza
- Watershed - Urban or rural watershed (described further in "Land Use")

3.10. Surface Type

Field Type: Text
Field Size: 25 characters
Example: Asphalt
Definition: Describes the predominant surface type associated with a Caltrans facility.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Landscape - Landscaping
- Asphalt - Asphalt only
- Concrete - Concrete only
- Asphalt/Concrete - Mixture of asphalt and concrete
- Right-of-Way - Right-of-Way (includes landscape, asphalt and/or concrete)
- Construction Site - Graded construction site

3.11. Land Use

Field Type: Text
Field Size: 4 characters
Example: R
Definition: Predominant land use of the tributary catchment area. This field describes the predominant land use of the area from which sampled runoff originates.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- R - Residential
- C - Commercial
- I - Industrial
- A - Agricultural
- F - Forest
- O - Open
- T - Transportation Facility (e.g., bridge, county road, highway, etc.)
- M - Mixed (no predominant land use can be discerned)

3.12. Catchment Area (ha)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 2.91
Definition: Total surface area in hectares (ha) draining to the point of collection of the storm water runoff sample.

3.13. Impervious Fraction

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 0.67
Definition: Estimated fraction of the catchment area that is effectively impervious. Impervious Fraction values will range from 0 – 1.

3.14. BMP Type

Field Type: Text
Field Size: 50 characters
Example: EDB
Definition: Describes the type of BMP represented by the monitoring site. This data field to be populated only for monitoring sites designed to treat storm water runoff. All non-BMP sites should have this data field value reported as "N/A".
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Retention - Retention Pond
- Swale - Biofiltration Swale
- EDB - Extended Detention Basin
- Wet Pond - Wet Detention Pond
- Dry Pond - Extended Dry Detention Pond
- Compost - Compost Media Filter
- Zeolite - Zeolite Media Filter
- SF - Sand Media Filter
- IB - Infiltration Basin
- IT - Infiltration Trench
- TCB - Trapping Catch Basin
- Insert - Drain Inlet Insert
- Strip - Biofiltration Strip
- Strip-Trench - Filtration Strip and Infiltration Trench Treatment Train
- Silt Fence - Silt Fence
- Gravel Bags - Gravel Bags (commonly used at construction sites)
- Sand Bags - Sand Bags (commonly used at construction sites)
- Straw Bales - Straw Bales (commonly used at construction sites)
- OWS - Oil/Water or Debris Separator
- MCTT - Mult-chambered Treatment Train
- CDS - Continuous Deflector Separator
- DBST - Double-Barrel Sand Trap
- DISump - Drain Inlet with Sump
- Wetland - Natural or man-made wetland
- DIC - Drain Inlet Cleaning
- Pickup - Gross Solids Pickup (gross solids studies)
- Sweep - Street Sweeping (gross solids studies)
- ModifyIn - Modified Inlet (gross solids studies)
- Grate - Bicycle Grate/LID (gross solids studies)
- ModGrate - Modified Bicycle Grate (gross solids studies)
- Baffle Box - Baffle Box (gross solids studies)
- FSVS - Forward Sloping V Screen (gross solids studies)
- RSVS - Reverse Sloping V Screen (gross solids studies)
- IBS - Inclined Bar Screen (gross solids studies)
- LRD - Linear Radial Device (gross solids studies)

Alternate Value: - N/A (see Definition above).

3.15. Point of Collection

Field Type: Text
Field Size: 20 characters
Example: Discharge
Definition: Describes the point of sample collection at the monitoring site.
Notes: Standardized Entry. Select value from standard list or contact database manager. Specifically with reference to any Gross Solids Removal Device (i.e., "litter" BMP device), "GSRD" is used to describe the Point of Collection of a gross solids sample removed from <u>any</u> part (i.e., drain system component) of the BMP. All water quality monitoring performed in parallel at gross solids monitoring sites will be conducted at distinct physical locations either upstream or downstream of the actual GSRD BMP. These associated upstream and downstream water quality monitoring sites will be assigned Point of Collection values of "Up GSRD" and "Down GSRD", respectively.

<u>Standard List</u>

- GSRD - Gross Solids Removal Device

3.16. Control Site

Field Type: Text
Field Size: 25 characters
Example: 7-147
Definition: The Caltrans Monitoring Site ID for the control or BMP "inlet" site associated with the BMP "outlet" or BMP "within" site in question. All non-BMP sites and BMP "inlet" sites should have this data field value reported as "N/A".
Notes: A small number of BMP sites do not possess a control or reference site. These sites should have this data field populated with the value "No Control for BMP".

Alternate Values: - N/A (see Definition above).
- No Control for BMP (see Notes above).

3.17. Cut-Fill

Field Type: Text
Field Size: 15 characters
Example: Cut
Definition: Identifies the roadway or facility as a cut, fill, grade or hybrid type (e.g., Grade/Fill) site.
Notes: Standardized Entry. Select value from standard list or contact database manager.

<u>Standard List</u>

- Cut - Sample collected from a cut area.
- Fill - Sample collected from a fill area.
- Grade - Sample collected from a grade area.
- Cut/Fill - Sample collected from a roadway or facility with both cut and fill areas.
- Grade/Cut - Sample collected from a roadway or facility with both grade and cut areas.
- Grade/Fill - Sample collected from a roadway or facility with both grade and fill areas.

3.18. Roadway Post Mile

Field Type: Text
Field Size: 18 characters
Example: SR-60-WB-15.29
Definition: A four-part descriptor that describes the roadway type, roadway number, traffic direction, and post mile of the Caltrans highway facility nearest to the monitoring site. If no such Post Mile exists for a site, the data field value should be reported as "N/A".
Notes: The Roadway Post Mile value is a compilation of the following four pieces of information: **Roadway Type-Roadway Number-Traffic Direction-Post Mile**
Standardized entries exist for roadway type and traffic direction.
Select values from standard lists or contact database manager.

Standard Lists

Roadway Type

- I - Interstate
- SR - State Route
- CR - County Road

Traffic Direction

- EB - Eastbound
- WB - Westbound
- NB - Northbound
- SB - Southbound

Alternate Value: - N/A (see Definition above).

3.19. Latitude

Field Type: Numeric
Field Size: Provide number to five (5) decimal places.
Example: 34.00970
Definition: Latitude of monitoring site in decimal degrees to five (5) decimal places.
Notes: Data should be collected using a differential GPS instrument with sufficient accuracy to report degrees to five decimal places.

3.20. Longitude

Field Type: Numeric
Field Size: Provide number to five (5) decimal places.
Example: 117.97470
Definition: Longitude of monitoring site in decimal degrees to five (5) decimal places.
Notes: Data should be collected using a differential GPS instrument with sufficient accuracy to report degrees to five decimal places

3.21. Datum

Field Type: Text
Field Size: 20 characters
Example: NAD 83
Definition: Datum by which latitude and longitude reported.

3.22. Rain Record Source

Field Type: Text
Field Size: 50 characters
Example: NOAA
Definition: Source of precipitation record used in precipitation estimates.
Notes: Report "Onsite" if rain gauge is located at the monitoring site, or report the name/location of the nearest rain gauge. Actual precipitation event record (i.e., rainfall data from rain gauge) should be included in a Time Series worksheet for the event (see Time Series data field description in this section).

3.23. Receiving Water Type

Field Type: Text
Field Size: 20 characters
Example: Intermittent
Definition: Type of receiving water sampled or into which storm water runoff is discharged.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Intermittent - Intermittent or seasonal stream or channel
- Wetlands - Seasonal or perennial wetlands
- River - Perennial freshwater river
- Stream - Perennial freshwater stream
- Lake - Freshwater lake or impoundment
- Pond - Freshwater pond
- Bay - Salt or brackish water bay
- Estuary - Salt or brackish water estuary
- Groundwater - Runoff percolates into soil profile surrounding monitoring site and ostensibly enters groundwater
- Ocean

3.24. AADT

Field Type: Numeric
Field Size: N/A
Example: 216600
Definition: Average annual daily traffic (AADT) flow at or near monitoring site.
Notes: If site is a maintenance yard, parking lot, or rest area, report the estimated number of vehicles entering and leaving the facility each day. Note that Southbound or Westbound traffic counts are usually represented by the "Back AADT" number provided in the AADT database, whereas the Northbound or Eastbound traffic counts are usually represented by the "Ahead AADT" number. For more information, please visit the following Caltrans web page:

http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/2002all.htm

3.25. AADT Source

Field Type: Text
Field Size: 100 characters
Example: http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/2003all.htm
Definition: Source or reference for reported AADT value.
Notes: A searchable AADT database is available at the Caltrans Traffic and Vehicle Data Systems Unit web page:

http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/

Note that Southbound or Westbound traffic counts are usually represented by the "Back AADT" number provided in the AADT database, whereas the Northbound or Eastbound traffic counts are usually represented by the "Ahead AADT" number.

3.26. Adjacent Lanes

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 2
Definition: The number of traffic lanes adjacent to the monitoring site that contribute storm water runoff that is sampled at the monitoring site's point of collection.
Notes: In many cases, the numeric value populating this data field will be a summation of the number of lanes of traffic moving in one direction only next to the monitoring site.

This data field need only be populated for HIGHWAY monitoring sites (i.e., monitoring sites having Runoff Characterization = "Hwy").

3.27. Total Lanes

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 4
Definition: The total number of traffic lanes (traffic moving in both directions) neighboring the monitoring site.
Notes: This data field should specify all lanes of traffic near the monitoring site that may impact storm water runoff through the deposition of airborne pollutants.

This data field need only be populated for HIGHWAY monitoring sites (i.e., monitoring sites having Runoff Characterization = "Hwy").

3.28. Time Series

Field Type: Text
Field Size: 50 characters
Example: Site 7-144 Time Series_2003-2004.xls
Definition: The name of the Excel worksheet in which time series data (flow, precipitation, etc.) collected at a monitoring site is submitted.
Notes: Times series data collected during storm events at a monitoring site can be submitted as multiple worksheets (one worksheet for each storm event) in a single workbook that represents all times series data collected at that site during an entire monitoring season. The Excel workbook file should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2003-2004 or 03-04) to which it corresponds.

3.29. Map

Field Type: Text
Field Size: 50 characters
Example: Site 7-144 Map_2003-2004.pdf
Definition: The name of the electronic document containing a map that shows the location of the monitoring site.
Notes: The actual electronic document containing a map of the monitoring site should be submitted along with the rest of the data collected for the site, including water quality data, time series data, and one or more photographs. The map should contain the clearly marked location of the monitoring site, latitude and longitude markers, and the watershed contributing flows to the site. The electronic map document should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2003-2004 or 03-04) to which it corresponds.

3.30. Photograph

Field Type: Text
Field Size: 75 characters
Example: Site 7-144 Photo_2003-2004.jpeg
Definition: The name of the electronic document containing photograph(s) of the monitoring site.
Notes: The actual electronic document containing photograph(s) of the monitoring site should be submitted along with the rest of the data collected for the site, including water quality data, time series data, and a map. The electronic photograph document should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2003-2004 or 03-04) to which it corresponds.

3.31. Site Notes

Field Type:	Text
Field Size:	255 characters
Example:	No AADT value provided for this site. Site is located along a county road for which no AADT data are available.
Definition:	This data field contains any notes or remarks about the monitoring site or various data fields used to describe the monitoring site.
Notes:	Data reporter should provide a note for any data field left blank. It is not appropriate to provide a note in a particular cell of a data field other than Site Notes. Considering the example above, it is not appropriate to place the note, "No AADT value provided for this site. Site is located along a county road for which no AADT data are available", in the AADT data field. The note must be entered into the Site Notes data field.

4. MEASURING UNITS CONVERSION TABLES

4.1. Length Conversions

Metric	Converting to >	Imperial
1 millimeter (mm)		0.0394 in
1 centimeter (cm)	10 mm	0.3937 in
1 meter (m)	100 cm	3.2808 ft
1 meter (m)	100 cm	1.0936 yd
1 kilometer (km)	1,000 m	0.6214 mile

Imperial	Converting to >	Metric
1 inch (in)		25.40 mm
1 inch (in)		2.54 cm
1 foot (ft)	12 in	0.3048 m
1 yard (yd)	3 ft	0.9144 m
1 mile	1,760 yd	1.6093 km

4.2. Area Conversions

Metric	Converting to >	Imperial
1 square cm (cm^2)	100 mm^2	0.1550 in^2
1 square m (m^2)	10,000 cm^2	1.1960 yd^2
1 hectare (ha)	10,000 m^2	2.4711 acres
1 square km (km^2)	100 ha	0.3861 $mile^2$

Imperial	Converting to >	Metric
1 square inch (in^2)		6.4519 cm^2
1 square foot (ft^2)	144 in^2	0.0929 m^2
1 square yard (yd^2)	9 ft^2	0.8361 m^2
1 acre	4840 yd^2	4046.9 m^2
1 acre	4840 yd^2	0.4047 ha
1 square mile ($mile^2$)	640 acres	2.59 km^2

4.3. Volume/Capacity Conversions

Metric	Converting to >	Imperial
1 cubic cm (cm^3)		0.0610 in^3
1 cubic decimeter (dm^3)	1,000 cm^3	0.0353 ft^3
1 cubic meter (m^3)	1,000 dm^3	1.3080 yd^3
1 liter (L)	1 dm^3	1.76 pt
1 hectoliter (hL)	100 L	21.997 gal

Imperial	Converting to >	Metric
1 cubic inch (in^3)		16.387 cm^3
1 cubic foot (ft^3)	1,728 in^3	0.0283 m^3
1 fluid ounce (fl oz)		29.5735 mL
1 pint (pt)	16 fl oz	0.4732 L
1 gallon (gal)	8 pt	3.785 L

4.4. Mass Conversions

Metric	Converting to >	Imperial
1 milligram (mg)		0.0154 grain
1 gram (g)	1,000 mg	0.0353 oz
1 kilogram (kg)	1,000 g	2.2046 lb
1 metric ton (t)	1,000 kg	2,204.6 lb

Imperial	Converting to >	Metric
1 ounce (oz)	437.5 grain	28.35 g
1 pound (lb)	16 oz	0.4536 kg
1 short ton (US)	2,000 lb	0.907 t

4.5. Temperature Conversions

Converting Degrees Fahrenheit to Degrees Celsius
Degrees Fahrenheit (°F) – 32 x 5/9 = Degrees Celsius (°C)

Converting Degrees Celsius to Degrees Fahrenheit
Degrees Celsius (°C) x 9/5 + 32 = Degrees Fahrenheit (°F)

SECTION 2.4

Caltrans Data Reporting Protocols: Toxicity

OCTOBER 2001

Caltrans Storm Water Management Program

2001-2002 Toxicity Data-Reporting Protocols

CTSW-TM-01-060

Prepared for:
California Department of Transportation
Environmental Program

GENERAL INSTRUCTIONS

(10/15/01)

Please read and be familiar with these general instructions. Toxicity and associated water quality data can only be accurately and expediently incorporated into the Caltrans Statewide Storm Water Database if these instructions are carefully followed. Adhering to these instructions will facilitate the processing of data and eliminate the need for time-consuming "record-by-record" data validation at year's end.

- **Get Monitoring Site IDs from Caltrans at the beginning of each monitoring season.**

  Caltrans will assign the "Monitoring Site ID". All Caltrans data reporters are required to contact the Caltrans database manager at the beginning of each sampling season to receive Monitoring Site IDs for each new site they will sample. Note that BMP sites having multiple points of collections (e.g., inlet, within, outlet) will be assigned a unique Monitoring Site ID for each point of collection. Data reporters shall provide the database manager with the names of each site, the Caltrans district in which each site resides, and the constituents that will be monitored at each site.

- **Enter data appropriately.**

  To facilitate the accurate entry of water quality data into Excel worksheets by Caltrans data reporters, and the subsequent transfer of this data into the Caltrans Statewide Storm Water Database, each data field described in this data-reporting protocol document possesses the following attributes: Field Name, Field Type, Field Size, Example, Definition, Notes (where applicable), Standard List (where applicable) and Alternate Value (where applicable). These eight data field attributes are defined below.

Field Name	Name of data field as it appears in the Excel data-reporting worksheet.
Field Type	Specifies the type of data, text or numeric, that can be stored in a field. Note: text fields can store both text and numbers.
Field Size	Specifies the number of characters that can be stored in a text field, or the number of decimal places required of a number entered into a numeric field.
Example	Provides an example of the data type and possible value that is appropriate for a specific data field.
Definition	Provides a definition of the data type and possible value that is appropriate for a specific data field.
Notes	Provides further information that may be helpful in appropriately and accurately populating a specific data field.
Standard List	Provides a list of standard values appropriate for populating a specific data field.
Alternate Value	Specifies if the use of "N/A" (not applicable) or "None" is an appropriate value for a specific data field.

Additionally, the following rules should be abided by when entering toxicity and associated water quality data into the Excel data-reporting worksheets provided by Caltrans.

- Select and enter text values only from the "Standard List" of values provided for each data field. Standardized values must be entered exactly as specified. Standard lists are included with the description of each data field where appropriate. If a standardized value provided for a particular data field does not accurately describe the data to be entered into that field, please contact the Caltrans database manager to discuss the creation of an additional value for a particular data field.

- **Use "Constituent"** names exactly as they appear in the constituent list, and report data in the units specified. Please refer to Section 4 at the end of these protocols for the list of "Standard Constituent Names".

- Enter numeric data values according to the definition provided for the particular numeric data field. Text must not be entered into numeric data fields. Text-based comments regarding a numeric value should be placed in the "Notes" data field.

- "Event ID" follows the format **YYYY-NN** ("Year monitoring season begins-Number of event at site beginning with 01"). Event IDs for the 2001-2002 Caltrans monitoring season would all begin with "2001". The first event monitored at any site shall be assigned an Event ID of "2001-01". Additional events at a particular site shall be numbered consecutively beginning with "2001-02".

- Use the correct system for date entries. Dates must be entered using the Excel "1900 Date System" typical for Windows (the "1900 Date System" is the default date system used by Microsoft Excel installed on Windows machines). The "Macintosh 1904 Date System" should be switched off in Excel preferences (located in the following nested menus: Tools >> Options >> Calculation).

- Values contained in data fields that link records from one Excel worksheet (or Access table) to another, such as Monitoring Site ID and Event ID, must match exactly for the correct relationship to exist between records once the data is imported into the Caltrans Statewide Storm Water Database (Version 2.0 built using Microsoft Access 2000). No match can be made between a Monitoring Site ID of "7 -21" (note an extra space between the 7 and the hyphen) found in the Site Descriptions worksheet and a Monitoring Site ID of "7-21" found in the Sample Descriptions worksheet. In general, wherever data field entries are hyphenated, do not include spaces.

- If any cell in a data field is left blank* (i.e., the data cell is null), a brief note explaining why the data cell was left blank must accompany the particular record. The brief note shall be placed in the "Notes" data field associated with the particular record containing one or more blank data cells.

  * Exceptions – The following data fields can contain null values without an associated note entered in the "Notes" data field of the relevant worksheet or data table:

Worksheet	Data Field
Sample Descriptions	Overall Qualifier
Aquatic Toxicity Sample Descriptions	Statistical Significance (with any result type except statistically significant difference).

- The use of "N/A" as a value entered into a text data field is acceptable for some fields where the data field definition does not apply to the particular data record being entered. For example, the data field "Control Site" (found in the Site Descriptions worksheet) applies only to Caltrans BMP sites for which a control site exists. This data field is "not applicable" to a non-BMP monitoring site with a "Point of Collection" equal to "Discharge". Data fields where the use of "N/A" is acceptable have this data value option specified in the Alternate Value attribute. "N/A" cannot be entered into a numeric data field. (***Additionally, the use of the value "Other" is no longer acceptable for any data field).***

- **Make sure that all required data records for a particular sampling event exist in the Sample Descriptions, Sampling Event Descriptions and Site Descriptions worksheets according to the following rules to maintain referential integrity among all related records:**

  - A Monitoring Site ID value (e.g., 7-21) contained in the Sample Descriptions worksheet must be represented by a single record for the same Monitoring Site ID in the Site Descriptions worksheet.

  - A Monitoring Site ID value (e.g., 7-21) contained in the Site Descriptions worksheet must be represented by at least one record in the Sample Descriptions worksheet.

  - A unique combination of Monitoring Site ID (e.g., 7-21) and Event ID (e.g., 2001-01) contained in the Sample Descriptions worksheet must be represented by a single record for the same unique Monitoring Site ID/Event ID pair in the Sampling Event Descriptions worksheet. Do not forget to create an Event Descriptions record for "non-storm" monitoring events (such as dry weather sampling, groundwater sampling, etc.) even though these events may not include the collection of precipitation and runoff data (Event ID, Site ID, Event Type, Sample Collector and Organization can be populated for these non-storm event records).

  - A unique combination of Monitoring Site ID (e.g., 7-21) and Event ID (e.g., 2001-01) found in the Sample Event Descriptions worksheet must be represented by at least one record in the Sample Descriptions worksheet having the same Monitoring Site ID/Event ID pair.

- **Do not report analytical results for blanks, duplicates, or reference toxicants. Report only values from environmental samples that have been QA/QC'ed.**

- **Use only Excel worksheets provided by Caltrans for the entry of water quality data.**

  All "Electronic Data Deliverables" (EDD) must be submitted in the format of the data-reporting worksheets provided by Caltrans. All data field headings should remain as they were originally entered into the worksheets at the time of their distribution to data reporters. Confirm that all data entered in the worksheets correspond to the appropriate data field headings.

- **Label all elements ofeach Electronic Data Deliverable (EDD) clearly**

  - The Excel workbook file containing worksheets storing Sample Descriptions, Sampling Event Descriptions, and Site Descriptions data should be labeled with the name of the data reporter (consultant or university), the title of the Caltrans activity under which the data was collected, and the monitoring season (e.g., 2001-2002 or 01-02) during which the data was collected.

    File naming convention for water quality data:

Water quality data file	CDM Dice Study_2001-2002
	UCLA First Flush Study_01-02

  - The submittal of supporting data and documents, such as time series data, maps, and photographs, should be labeled with the Caltrans Monitoring Site ID and monitoring season to which they correspond. Times series data collected during storm events at a monitoring site can be submitted as multiple worksheets (one worksheet for each storm event) in a single workbook that represents all times series data collected at that site during an entire monitoring season.

    File naming conventions for supporting data:

Time series file	Site 7-21 Time Series_2001-2002.xls
Map file	Site 7-21 Map_2001-2002.pdf
Photograph file	Site 7-21 Photo_2001-2002.jpeg

  - When submitting an EDD to the Caltrans database manager, please compile all files (toxicity and associated water quality data, including sample, event and site descriptions, time series data, maps and photographs) onto one or more recordable compact discs (CD-R) labeled with the data reporter's name and date of data submittal. Mail CD(s) to the database manager at the address provided below.

- **Please notify Caltrans of any errors or inconsistencies found in this document, or any changes you might recommend.**

Definition of a Precipitation Event

For the purposes of these protocols, a precipitation event shall begin with six consecutive hours during which a sum total of at least 2.54 mm (0.1 inches) of rain falls, and end with six consecutive hours in each of which no rainfall greater than 0.254 mm (0.01 inches) of rain is recorded. The precipitation event so identified shall be truncated so that it both begins and ends in hours with rainfallequal to or greater than 0.254 mm (0.01 inches).

Summary Toxicity Information

Table 1 below presents a summary of associated toxicity data. This table should serve as a reference when inputing data into the aquatic toxicity sample description portion of the database.

Test Method	Endpoint(s) Tested	Result Types (units)	
Test Type		**Screening Level**	**Dilution Series**
Acute *Ceriodaphnia dubia, Pimephales Promelas,* and *Oncorynchus mykiss*	Mortality	• Mean mortality (%) • Statistically significant difference from control (yes/no) • Standard error (%)	• Mean mortality (%) • Standard error (%) • LC_{50} (% dilution) • NOEC/LOEC (% dilution) • Acute Toxic Units (TUa)
Chronic *Ceriodaphnia dubia, Pimephales promelas*, and *Oncorynchus mykiss*	Mortality	• Mean mortality (%) • Statistically significant difference from control (yes/no) • Standard error (%)	• Mean mortality (%) • Standard error (%) • LC_{50} (% dilution) • NOEC/LOEC (% dilution) • Chronic Toxic units (TUc)
Chronic *Ceriodaphnia dubia*	Reproduction	• Mean reproduction (neonates/adult) • Statistically significant difference from control (yes/no) • Standard error (neonates/adult)	• Mean reproduction (neonates/adult) • Standard error (neonates/adult) • $EC_{50,}$ EC_{25} etc. (% dilution) • NOEC/LOEC (% dilution) • Chronic Toxic units (TUc)
Chronic *Pimephales promelas*	Growth	• Mean growth (mg/individual) • Statistically significant difference from control (yes/no) • Standard error (mg/individual)	• Mean growth (mg/individual) • Standard error (mg/individual) • $IC_{50,}$ IC_{25} etc. (% dilution) • NOEC/LOEC (% dilution) • Chronic Toxic units (TUc)
Chronic *Selenastrum capricornutum*	Growth (cell number)	• Mean growth (cells/mL) • Statistically significant difference from control (yes/no) • Standard error (cells/mL)	• Mean growth (cells/mL) • Standard error (cells/mL) • $IC_{50,}$ IC_{25} etc. (% dilution) • NOEC/LOEC (% dilution) • Chronic Toxic units (TUc)

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1. WATER QUALITY SAMPLE DESCRIPTIONS

1.1. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-21
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located.

1.2. Event ID

Field Type: Text
Field Size: 8 characters
Example: 2001-01
Definition: A unique, site-specific identification number assigned to a sampling event.
Notes: Event ID follows the format YYYY-NN ("Year monitoring season begins-Number of event at site beginning with 01"). The first event at any site would be assigned an Event ID of "Year-01". Additional events at a particular site shall be numbered consecutively beginning with "Year-02". Even if a site isn't monitored until the latter half of the monitoring season (e.g., Site X is monitored during Feb. – Apr. 2002 – the latter half of the 2001-2002 monitoring season), its Event IDs include the year in which the general Caltrans monitoring season began (e.g., samples collected during the first event at Site X in Feb. 2002 are assigned Event IDs of "2001-01").

1.3. Sample Start Date

Field Type: Date
Field Size: n/a
Example: 11/05/2001
Definition: Date on which composite sampling begins or grab sample is collected. In regard to composite samples, specifically the date on which the sampler was activated <u>and</u> the flow meter began totalizing flow.
Notes: Formatted as mm/dd/yyyy.

1.4. Sample Start Time

Field Type: Time
Field Size: n/a
Example: 15:24
Definition: Time at which composite sampling begins or grab sample is collected. In regard to composite sampling, specifically the time at which the sampler was activated <u>and</u> the flow meter began totalizing flow.
Notes: Formatted for 24-hour clock (hh:mm).

1.5. Sample End Date

Field Type: Date
Field Size: n/a
Example: 11/05/2001
Definition: Date on which composite sampling ends. Specifically, the date on which the sampler was de-activated and/or the flow meter stopped totalizing flow.
Notes: Formatted as mm/dd/yyyy.

1.6. Sample End Time

Field Type: Time
Field Size: n/a
Example: 15:24
Definition: Time at which composite sampling ends. Specifically, the time at which the sampler was de-activated and/or the flow meter stopped totalizing flow.
Notes: Formatted for 24-hour clock (hh:mm).

1.7. Sample Source

Field Type: Text
Field Size: 12 characters
Example: Storm
Definition: Identifies the source of the water quality sample analyzed.
Notes: Standardized Entry. Enter value from standard list or contact database manager.

Standard List

- Storm - Sample from storm water(rainfall) runoff
- Rain - Sample from rainwater collected directly from the atmosphere
- Receiving - Sample from receiving water
- Vadose - Sample from vadose zone
- Sediment - Sample from deposited sediment
- Base - Sample from dry-weather base flow
- Groundwater - Sample from groundwater
- Non-storm - Sample from non-storm water runoff
- BMP media - Sample from material used to construct BMP device

1.8. Event Representation

Field Type: Text
Field Size: 12 characters
Example: FF
Definition: Describes the part of the event represented by the sample.
Notes: Standardized Entry. Enter value from standard list or contact database manager.
Standard List

- FF - Event first flush
- Peak - Event peak flow
- Whole - Whole storm
- Discrete - One or more discrete samples collected during an event that cannot be described as representing the first flush, peak or whole storm portion of the event. This value will typically, although not exclusively, be used for a "Non-storm" Sample Source.
- X-hr Comp - Used to describe a planned composite sampling event lasting X hours.

1.9. Sample Type

Field Type: Text
Field Size: 2 characters
Example: C
Definition: Describes the way in which sample was collected.
Notes: Standardized Entry. Enter value from standard list or contact database manager.
Standard List

- C - Composite Sample: A sample made up of multiple sub-samples (aliquots) collected over some spatial or temporal scale.
- G - Grab Sample: A single sample that represents conditions at a distinct point in time.

1.10. Sample Matrix

Field Type: Text
Field Size: 10 characters
Example: Water
Definition: Matrix from which sample was analyzed.
Notes: Standardized Entry. Enter value from standard list or contact database manager.
Standard List

- Water

Note: Other sample matrices, such as sediment, sludge, soil, solid, etc. are now included in the 2001-2002 Sediment Data-Reporting Protocols document.

1.11. Constituent Type

Field Type: Text
Field Size: 4
Example: CON
Definition: Describes the type or class of constituent analyzed.
Notes: Standardized Entry. Enter value from standard list or contact database manager.

Standard List

- CON - Conventionals
- MIN - Minerals
- N - Nutrients

1.12. CAS Number

Field Type: Text
Field Size: 15 characters
Example: 7440-50-8
Definition: CAS Number (Chemical Abstracts Service Registry Number) or Caltrans Constituent ID number for constituent.

Standard List

- Alkalinity as CaCO3 CT-ALKCACO3
- DO CT-DO
- EC (µmhos/cm) CT-EC
- Hardness as CaCO3 CT-HARD
- pH (pH units) CT-PH
- Temperature (^{o}C) CT-TEMP
- Chlorine Residual CT-CLRES
- NH3-N CT-NH3N

1.13. Constituent

Field Type: Text
Field Size: 40 characters
Example: Cu
Definition: Name of constituent as found in the Caltrans Statewide Storm Water Database.
Notes: Standardized Entry. Enter value from standard list or contact database manager.

Standard List

- Alkalinity
- DO
- EC
- Hardness
- pH
- Temperature
- Chlorine Residual
- NH3-N

1.14. Fraction

Field Type: Text
Field Size: 6 characters
Example: N/A
Definition: Describes fraction of constituent analyzed.
Notes: Standardized Entry. Dissolved or total fractions are not applicable to the analytical constituents associated with toxicity samples (as listed above in 1.13). However, THIS DATA FIELD CAN NO LONGER BE LEFT BLANK/NULL. Therefore, these constituents should receive a value of "N/A" (not applicable) to describe their fraction analyzed.

1.15. Numerical Qualifier

Field Type: Text
Field Size: 1 character
Example: <
Definition: An indication of what the Reported Value for an analyzed sample represents (i.e., a minimum, maximum or "exact" value).
Notes: Standardized Entry. Enter value from standard list or contact database manager. Please refer to Overall Qualifier (see data field 1.17. below) for additional guidance on the appropriate qualification of water quality results.

Standard List

- < - Actual value of analyzed sample is less than reported value. This symbol must be used for all "non-detect" samples.
- = - Value of analyzed sample is as reported.
- > - Actual value of analyzed sample is greater than reported value.

1.16. Reported Value

Field Type: Numeric
Field Size: n/a
Example: 0.25
Definition: Reported laboratory result of analyzed sample.
Notes: Reported Value must equal Reporting Limit if associated Numerical Qualifier is "<".

1.17. Overall Qualifier

Field Type: Text
Field Size: 4 characters
Example: U
Definition: An overall data validation qualifier based on lab results and associated quality assurance/quality control (QAQC) analyses.
Notes: Standardized Entry. Enter value from standard list or contact database manager. The qualifiers and definitions presented below represent a compilation of data qualifiers used by specific EPA programs as noted in: (1) *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 1994); and (2) *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999).

Standard List

- U - The material was analyzed for, but was not detected above the level of the associated value (the associated value represents a reporting limit that may or may not be elevated due to blank contamination).
- J - The associated value is approximate (i.e., an estimated quantity).
- N - The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification".
- NJ - The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
- UJ - The material was analyzed for, but was not detected. The associated value (i.e., reporting limit) is an estimate and may be inaccurate or imprecise.
- R - The sample result is rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

1.18. Units

Field Type: Text
Field Size: 12 characters
Example: mg/L
Definition: Describes the unit of measure associated with the Reported Value.
Notes: Standardized Entry. Enter value from standard list or contact database manager. Report sample results in the appropriate unit associated with a particular constituent as specified in the standardized list. Use capital "L" for liter abbreviation. Confirm that values for Reported Value, Method Detection Limit, and Reporting Limit are all reported in the same units for individual sample records.

Standard List

- Alkalinity mg/L
- DO mg/L
- EC µmhos/cm
- Hardness mg/L
- pH pH units
- Temperature ^{o}C
- Chlorine Residual mg/L
- NH3-N mg/L

1.19. Preparation Method

Field Type: Text
Field Size: 40 characters
Example: Separatory Funnel
Definition: Describes the preparation a sample underwent prior to analysis. All samples receiving no form of preparation prior to analysis should have this data field value reported as "None".
Notes: Standardized Entry. Enter value from standard list or contact database manager.
Standard List

- Hot Plate
- Microwave
- Purge and Trap
- Methanol Extraction
- Continuous
- Separatory Funnel
- Soxhlet
- Ultrasonic Extraction
- Solid Phase Extraction - for water samples
- Accelerated Solvent Extraction

Alternate Value: - None (see Definition above).

1.20. Method Reference

Field Type: Text
Field Size: 10 characters
Example: EPA
Definition: Provides the reference for the analytical method used to evaluate the sample.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- EPA - US Environmental Protection Agency.
- SM - Standard Methods.
- Field - Constituent evaluated in the field. Note: no Method Numbers are associated with field-measured constituents.
- Caltrans - Caltrans-defined analytical method.

1.21. Method Number

Field Type: Text
Field Size: 10 characters
Example: 625
Definition: Reference number for the analytical method used to evaluate the sample.
Notes: By convention, method numbers that contain a text suffix do not include a space between the number and the text suffix (e.g., 6010A).

1.22. Method Detection Limit

Field Type: Numeric
Field Size: n/a
Example: 0.2
Definition: Method Detection Limit (MDL) – The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from the analysis of a sample in a given matrix containing the analyte.
Notes: Concentrations reported by a laboratory that are between the MDL and Reporting Limit (see data field 1.23. below) are usually flagged by the laboratory as estimated "J", indicating that the constituent is present but its concentration cannot be accurately quantified (see data field 1.17, Overall Qualifier, for further information on data validation qualifiers).

1.23. Reporting Limit

Field Type: Numeric
Field Size: n/a
Example: 1.0
Definition: Reporting Limit (RL) as reported by laboratory. This value is the lowest concentration of a constituent that can be reliably quantified within specified limits of precision and accuracy during routine laboratory operating conditions. Reporting Limit is equivalent to Practical Quantitative Limit (PQL) and Reported Detection Limit (RDL).
Notes: The RL may be elevated above the Caltrans "target" RL due to matrix interference.

1.24. Collection Method

Field Type: Text
Field Size: 6 characters
Example: Auto
Definition: Describes the way in which a sample was collected.
Notes: Standardized Entry. Select value from standard list or contact database manager.
<u>Standard List</u>

- Auto - Sample aliquot collected by automated sampling device.
- Manual - Sample aliquot collected manually.

1.25. Field Sample ID

Field Type: Text
Field Size: 35 characters
Example: 134-0010-281500A
Definition: Field identification number assigned to sample/sample vessel.
Notes: This data field can contain any combination of text and numeric characters.

1.26. Lab Name

Field Type: Text
Field Size: 25 characters
Example: APPL
Definition: Name of laboratory that analyzed sample.
Notes: Standardized Entry. Select value from standard list. The list of analytical laboratories used by the Caltrans Storm Water Management Program will likely change over time, and therefore the Standard List below might not include the name of every laboratory used in any given monitoring year.

Standard List

- APPL - Agriculture & Priority Pollutants Labs
- Aquascience
- Aquatic Bioassay and Consulting (ABC) Laboratory
- Associated Labs
- BSK
- CEL - Calscience Environmental Labs
- Del Mar Analytic
- GeoAnalytical Labs
- North Coast Labs
- Pat-Chem
- Quanterra
- Silliker
- Soil Control Lab
- ToxScan
- UCDATL -UC Davis Aquatic Toxicity Lab

1.27. Lab Sample ID

Field Type: Text
Field Size: 25 characters
Example: 120085-400A
Definition: Laboratory identification number assigned to sample by analytical laboratory.
Notes: This data field can contain any combination of text and numeric characters.

1.28. Contract Number

Field Type: Text
Field Size: 12 characters
Example: 43A005
Definition: Caltrans contract number under which sample was collected.
Notes: This data field can contain any combination of text and numeric characters.

1.29. Task Order Number

Field Type: Text
Field Size: 6 characters
Example: 11
Definition: Caltrans task order number under which sample was collected.

Notes: This data field can contain any combination of text and numeric characters.

1.30. Sample Notes

Field Type: Text
Field Size: 255 characters
Example: Sample End Time missing due to malfunctioning automated sampler.
Definition: This data field contains any notes or remarks about the sample or various data fields used to describe the sample.
Notes: Data reporter should provide a note for any data field left blank (with the exception of Overall Qualifier). It is not appropriate to provide a note in a particular cell of a data field other than Sample Notes. Considering the example above, it is not appropriate to place the note, "Sample End Time missing due to malfunctioning automated sampler", in the Sample End Time data field. The note must be entered into the Sample Notes data field.

2. WATER QUALITY SAMPLING EVENT DESCRIPTIONS

2.1. Event ID

Field Type: Text
Field Size: 8 characters
Example: 2001-01
Definition: A unique, site-specific identification number assigned to a sampling event.
Notes: Event ID follows the format "Year monitoring season begins-Number of event at site beginning with 01". The first event at any site would be assigned an Event ID of "Year-01". Additional events at a particular site shall be numbered consecutively beginning with "Year-02". Even if a site isn't monitored until the latter half of the monitoring season (e.g., Site X is monitored during Feb. – Apr. 2002 – the latter half of the 2001-2002 monitoring season), its Event IDs include the year in which the general Caltrans monitoring season began (e.g., samples collected during the first event at Site X in Feb. 2002 are assigned Event IDs of "2001-01").

2.2. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-21
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located.

2.3. Event Type

Field Type: Text
Field Size: 10 characters
Example: Non-storm
Definition: Describes if sampling event is associated with a storm event or a non-storm event.
Notes: Standardized Entry. Select value from standard list or contact database manager. This data field quickly describes whether an event record includes precipitation and flow data (i.e., event is a storm event) or does notnecessarily include such precipitation and flow data (i.e., event is a non-stormevent, such as a dry weather or groundwatersampling event; note: flow data could be provided for a dry weather event). Storm event records that are missing various precipitation and flow data due to malfunctioning equipment must be described with Event Type equal to "Storm" and include remarks in their Event Notes data field as to why certain data are missing.

<u>Standard List</u>

- Storm
- Non-storm

2.4. Rain Start Date

Field Type: Date
Field Size: n/a
Example: 11/05/2001
Definition: Date on which precipitation event begins.
Notes: Formatted as mm/dd/yyyy. See "Definition of a Precipitation Event" in the General Instructions section of this document.

2.5. Rain Start Time

Field Type: Time
Field Size: n/a
Example: 15:24
Definition: Time at which precipitation event begins.
Notes: Formatted for 24-hour clock (hh:mm). See "Definition of a Precipitation Event" in the General Instructions section of this document.

2.6. Rain End Date

Field Type: Date
Field Size: n/a
Example: 11/05/2001
Definition: Date on which precipitation event ends.
Notes: Formatted as mm/dd/yyyy. See "Definition of a Precipitation Event" in the General Instructions section of this document.

2.7. Rain End Time

Field Type: Time
Field Size: n/a
Example: 15:24
Definition: Time at which precipitation event ends.
Notes: Formatted for 24-hour clock (hh:mm). See "Definition of a Precipitation Event" in the General Instructions section of this document.

2.8. Event Rain (mm)

Field Type: Numeric
Field Size: Provide number only to three (3) decimal places.
Example: 15.989
Definition: Total rain at site for an event in millimeters (mm).
Notes: The Site Descriptions data field named Rain Record Source identifies the source of the Event Rain data for a particular monitoring site. See "Definition of a Precipitation Event" in the General Instructions section of this document.

2.9. Max Intensity (mm/hr)

Field Type: Numeric
Field Size: Provide number only to three (3) decimal places.
Example: 12.183
Definition: Peak 5-minute intensity of a storm event in millimeters/hour (mm/hr).
Notes: Maximum Intensity is calculated as twelve times (12 x) the maximum rainfall recorded in any 5-minute period.

2.10. Antecedent Dry (days)

Field Type: Numeric
Field Size: Provide number only to one (1) decimal place.
Example: 12.0
Definition: Days since the end of the most recent prior Caltrans-defined precipitation event (whether monitored or not). If datum exists, irrespective of whether the prior event was monitored, data reporter should include Antecedent Dry datum as part of the Event Record for the current event.
Notes: See "Definition of a Precipitation Event" in the General Instructions section of this document.

2.11. Antecedent Event Rain (mm)

Field Type: Numeric
Field Size: Provide number only to three (3) decimal places.
Example: 24.365
Definition: Total rain at site forthe most recent antecedent precipitation event in millimeters (mm). The antecedent precipitation event used for this data field should be the <u>same</u> antecedent precipitation event referenced in the Antecedent Dry data field. The quantification of Antecedent Event Rain does <u>not</u> include "inter-event" precipitation.
Notes: Using the examples provided above for Antecedent Dry and Antecedent Event Rain, the antecedent or prior precipitation event for Site X occurred 12.0 days ago, and delivered 24.37 mm of rainfall. The antecedent precipitation event must meet Caltrans' criteria for a precipitation event. See "Definition of a Precipitation Event" in the General Instructions section of this document.

2.12. Peak Capture

Field Type: Text
Field Size: 8 characters
Example: Y
Definition: Indication of whether peak flow was captured during sampling event.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Y - Yes, peak flow was captured.
- N - No, peak flow was not captured.

2.13. Runoff Start Date

Field Type: Date
Field Size: n/a
Example: 11/05/2001
Definition: Date on which first runoff begins.
Notes: Formatted as mm/dd/yyyy.

2.14. Runoff Start Time

Field Type: Time
Field Size: n/a
Example: 15:24
Definition: Time at which first runoff begins.
Notes: Formatted for 24-hour clock (hh:mm).

2.15. Runoff End Date

Field Type: Date
Field Size: n/a
Example: 11/05/2001
Definition: Date on which last runoff ceases.
Notes: Formatted as mm/dd/yyyy.

2.16. Runoff End Time

Field Type: Time
Field Size: n/a
Example: 15:24
Definition: Time at which last runoff ceases.
Notes: Formatted for 24-hour clock (hh:mm)

2.17. Total Flow Volume (L)

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 38686
Definition: Total measured flow volume in liters (L) at a monitoring site for an event.

2.18. Peak Flow (L/s)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 3.40
Definition: Estimated peak flow of runoff in liters per second (L/s) at a monitoring site for an event.

2.19. Estimated Percent Capture

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 99
Definition: Estimated percentage of total event flow volume during which monitoring was performed (i.e., while the sampler was activated and flow-proportioned sample collection was successfully occurring). Report datum only if estimate is based on actual runoff and sample collection data measured by an instrument located at the monitoring site in question.
Notes: Periods of sampler malfunction or failure to collect sample must be excluded from the "captured flow".

2.20. Cumulative Precipitation (mm)

Field Type: Numeric
Field Size: Provide number only to three (3) decimal places.
Example: 100.761
Definition: Estimated cumulative precipitation in millimeters (mm) at monitoring site since the beginning of the water year (October 1), up to the Rain Start Date/Time for the monitored event. All precipitation that has fallen to date at a site, including "inter-event" precipitation, should be included in the Cumulative Precipitation value reported for that site for a particular event.

2.21. Sample Collector

Field Type: Text
Field Size: 25 characters
Example: Peggie Sampson
Definition: Name of the individual who collected the sample.

2.22. Organization

Field Type: Text
Field Size: 30 characters
Example: Acme Environmental
Definition: Organization to which the sample collector is associated.

2.23. Event Notes

Field Type: Text
Field Size: 255 characters
Example: Runoff End Time missing due to malfunctioning flow meter.
Definition: This data field contains any notes or remarks about the sampling event or various data fields used to describe the sampling event.
Notes: Data reporter should provide a note for any data field left blank. It is not appropriate to provide a note in a particular cell of a data field other than Event Notes. Considering the example above, it is not appropriate to place the note, "Runoff End Time missing due to malfunctioning flow meter", in the Runoff End Time data field. The note must be entered into the Event Notes data field.

3. WATER QUALITY SITE DESCRIPTIONS

3.1. Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-21
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located.

3.2. Monitoring Year

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 2001
Definition: Identifies the monitoring season a site is monitored by populating the data field with the year the current monitoring season begins.
Notes: In regard to the 2001-2002 monitoring season, the Monitoring Year value for each site monitored would be "2001" – the year the current monitoring season began. The term Monitoring Year refers to only a single calendar year, while the term Monitoring Season necessarily refers to two calendar years, such as 2001-2002.

3.3. Site Name

Field Type: Text
Field Size: 100 characters
Example: DICE Site 12/23
Definition: Name of monitoring site.
Notes: Site Name is meant to be a shorthand designation for the monitoring site, and the "common name" by which the sampling crew and data reporter refer to the site.

3.4. Site Description

Field Type: Text
Field Size: 255 characters
Example: East of Ocean View Avenue Onramp to EB 210 Fwy; a low-density residential site within foothills.
Definition: Describes monitoring site in some detail, including observations related to site's location and physical characteristics.
Notes: In addition to the above definition, this field can be used to describe changes observed at the site since the prior monitoring season.

3.5. Caltrans District

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 7
Definition: Caltrans district in which monitoring site is located.

3.6. Hydrologic Sub-Area

Field Type: Numeric
Field Size: Provide 5-digit number in the format XXX.XX
Example: 405.32
Definition: State Water Resources Control Board (SWRCB) Hydrologic Unit Sub-Area in which monitoring site is located.
Notes: SWRCB Hydrologic codes are 6-byte strings composed of numbers and a decimal point. The meaning associated with each byte position is shown below.

Byte(s)	Meaning
1	Hydrologic Region
2,3	Hydrologic Unit
4	always a decimal point
5	Hydrologic Area
6	Hydrologic Sub-Area

Hydrologic sub-areas are typically identified in Basin Plans. They may also be found at the Water Quality Standards Inventory Database web site: http://endeavor.des.ucdavis.edu/wqsid/region.asp

3.7. County

Field Type: Text
Field Size: 20 characters
Example: Los Angeles
Definition: County in which monitoring site is located.
Notes: It is not necessary to include the word "County" along with the actual name of the county in which the monitoring site is located.

3.8. RWQCB

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 4
Definition: Regional Water Quality Control Board (RWQCB) region in which monitoring site is located.

3.9. Runoff Characterization

Field Type: Text
Field Size: 15 characters
Example: Hwy
Definition: Type of runoff characterized by samples collected from monitoring site.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Hwy - Highway or Freeway
- Maintenance - Maintenance facility
- Bridge - Bridge
- Parking - Parking lot (e.g., Park & Ride facility)
- Rest Area - Rest area
- A/D - Acceleration/Deceleration area
- Construction - Construction
- BMP - Site designed for storm water treatment
- Receiving - Receiving water (described further in "Receiving Water Type)
- Watershed - Municipal or rural watershed (described further in "Land Use")

3.10. Surface Type

Field Type: Text
Field Size: 25 characters
Example: Pavement
Definition: Describes the predominant surface type associated with a Caltrans facility.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Landscape - Landscaping
- Pavement - Pavement only
- Right-of-Way - Right-of-Way (includes landscape and pavement)

3.11. Land Use

Field Type: Text
Field Size: 4 characters
Example: R
Definition: Predominant land use of the tributary catchment area. This field describes the predominant land use of the area from which sampled runoff originates.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- R - Residential
- C - Commercial
- I - Industrial
- A - Agricultural
- F - Forest
- O - Open
- T - Transportation Facility (e.g., bridge, county road, highway, etc.)
- M - Mixed (no predominant land use can be discerned)

3.12. Catchment Area (ha)

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 2.91
Definition: Total surface area in hectares (ha) draining to the point of collection of the storm water runoff sample.

3.13. Impervious Fraction

Field Type: Numeric
Field Size: Provide number only to two (2) decimal places.
Example: 0.67
Definition: Estimated fraction of the catchment area that is effectively impervious.

3.14. BMP Type

Field Type: Text
Field Size: 35 characters
Example: EDB
Definition: Describes the type of BMP represented by the monitoring site. This data field to be populated only for monitoring sites designed to treat storm water runoff. All non-BMP sites should have this data field value reported as "N/A".
Notes: Standardized Entry. Select value from standard list or contact database manager.

<u>Standard List</u>

- Retention - Retention Pond
- Swale - Biofiltration Swale
- EDB - Extended Detention Basin
- Wet Pond - Wet Detention Pond
- Dry Pond - Extended Dry Detention Pond
- Compost - Compost Media Filter
- Zeolite - Zeolite Media Filter
- SF - Sand Media Filter
- IB - Infiltration Basin
- IT - Infiltration Trench
- TCB - Trapping Catch Basin
- Insert - Drain Inlet Insert
- Strip - Biofiltration Strip
- Strip-Trench - Filtration Strip and Infiltration Trench Treatment Train
- OWS - Oil/Water or Debris Separator
- MCTT - Mult-chambered Treatment Train
- CDS - Continuous Deflector Separator
- DIC - Drain Inlet Cleaning
- Pickup - Litter Pickup (litter studies)
- Sweep - Street Sweeping (litter studies)
- ModifyIn - Modified Inlet (litter studies)
- Grate - Bicycle Grate/LID (litter studies)
- ModGrate - Modified Bicycle Grate (litter studies)

Alternate Value: - N/A (see Definition above).

3.15. Point of Collection

Field Type: Text
Field Size: 12 characters
Example: Discharge
Definition: Describes the point of sample collection at the monitoring site.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Discharge - Outfall to receiving water or outlet to conveyance system
- Inlet - Inlet to BMP
- Outlet - Outlet to BMP
- Within - Somewhere within BMP
- Bypass
- Overflow
- Overland - Overland flow
- Receiving - Location(s) in receiving water (stream, lake, etc.)

3.16. Control Site

Field Type: Text
Field Size: 20 characters
Example: 7-156
Definition: The Caltrans Monitoring Site ID for the control or BMP "inlet" site associated with the BMP "outlet" or BMP "within" site in question. All non-BMP sites and BMP "inlet" sites should have this data field value reported as "N/A".
Notes: A small number of BMP sites do not possess a control or reference site. These sites should have this data field populated with the value "No Control for BMP".

Alternate Values: - N/A (see Definition above).
- No Control for BMP (see Notes above).

3.17. Cut-Fill

Field Type: Text
Field Size: 15 characters
Example: Cut
Definition: Identifies the roadway or facility as a cut, fill, grade or hybrid type (e.g., Grade/Fill) site.
Notes: Standardized Entry. Enter value from standard list or contact database manager.
Standard List

- Cut - Sample collected from a cut area.
- Fill - Sample collected from a fill area.
- Grade - Sample collected from a grade area.
- Cut/Fill - Sample collected from a roadway or facility with both cut and fill areas.
- Grade/Cut - Sample collected from a roadway or facility with both grade and cut areas.
- Grade/Fill - Sample collected from a roadway or facility with both grade and fill areas.

3.18. Roadway Post Mile

Field Type: Text
Field Size: 18 characters
Example: I-210-EB-18.45
Definition: A four-part descriptor that describes the roadway type, roadway number, traffic direction, and post mile of the Caltrans highway facility nearest to the monitoring site. If no such Post Mile exists for a site, the data field value should be reported as "N/A".
Notes: The Roadway Post Mile value is a compilation of the following four pieces of information: **Roadway Type-Roadway Number-Traffic Direction-Post Mile**
Standardized entries exist for roadway type and traffic direction.
Select values from standard lists or contact database manager.

Standard Lists

Roadway Type

- I - Interstate
- SR - State Route
- CR - County Road

Traffic Direction

- EB - Eastbound
- WB - Westbound
- NB - Northbound
- SB - Southbound

Alternate Value: - N/A (see Definition above).

3.19. Latitude

Field Type: Numeric
Field Size: Provide number to five (5) decimal places.
Example: 34.20969
Definition: Latitude of monitoring site in decimal degrees to five (5) decimal places.
Notes: Data should be collected using a differential GPS instrument with sufficient accuracy to report degrees to five decimal places.

3.20. Longitude

Field Type: Numeric
Field Size: Provide number to five (5) decimal places.
Example: 118.22469
Definition: Longitude of monitoring site in decimal degrees to five (5) decimal places.
Notes: Data should be collected using a differential GPS instrument with sufficient accuracy to report degrees to five decimal places

3.21. Datum

Field Type: Text
Field Size: 20 characters
Example: NAD 83
Definition: Datum by which latitude and longitude reported.
Notes: NAD 27 Conus is the preferred datum.

3.22. Rain Record Source

Field Type: Text
Field Size: 50 characters
Example: NOAA
Definition: Source of precipitation record used in precipitation estimates.
Notes: Report "Onsite" if rain gauge is located at the monitoring site, or report the name/location of the nearest rain gauge. Actual precipitation event record (i.e., rainfall data from rain gauge) should be included in a Time Series worksheet for the event (see Time Series data field description in this section).

3.23. Receiving Water Type

Field Type: Text
Field Size: 20 characters
Example: Intermittent
Definition: Type of receiving water sampled or into which storm water runoff is discharged.
Notes: Standardized Entry. Select value from standard list or contact database manager.

Standard List

- Intermittent - Intermittent or seasonal stream or channel
- Wetlands - Seasonal or perennial wetlands
- River - Perennial freshwater river
- Stream - Perennial freshwater stream
- Lake - Freshwater lake or impoundment
- Pond - Freshwater pond
- Bay - Salt or brackish water bay
- Estuary - Salt or brackish water estuary
- Ocean
- Onsite Infiltration - Runoff percolates into soil profile surrounding monitoring site

3.24. AADT

Field Type: Numeric
Field Size: n/a
Example: 120000
Definition: Average annual daily traffic (AADT) flow at or near monitoring site.
Notes: If site is a maintenance yard, parking lot, or rest area, report the estimated number of vehicles entering and leaving the facility each day.

3.25. AADT Source

Field Type: Text
Field Size: 100 characters
Example: http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/1999all.htm
Definition: Source or reference for reported AADT value.
Notes: A searchable AADT database is available at the Caltrans Traffic and Vehicle Data Systems Unit web page:
http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/

3.26. Total Lanes

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 4
Definition: The total number of traffic lanes (moving in both directions) of the Caltrans highway facility nearest to the monitoring site.

3.27. Time Series

Field Type: Text
Field Size: 50 characters
Example: Site 7-21 Time Series_2001-2002.xls
Definition: The name of the Excel worksheet in which time series data (flow, precipitation, etc.) collected at a monitoring site is submitted.
Notes: Times series data collected during storm events at a monitoring site can be submitted as multiple worksheets (one worksheet for each storm event) in a single workbook that represents all times series data collected at that site during an entire monitoring season. The Excel workbook file should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2001-2002 or 01-02) to which it corresponds.

3.28. Map

Field Type: Text
Field Size: 50 characters
Example: Site 7-21 Map_2001-2002.pdf
Definition: The name of the electronic document containing a map that shows the location of the monitoring site.
Notes: The actual electronic document containing a map of the monitoring site should be submitted along with the rest of the data collected for the site, including water quality data, time series data, and one or more photographs. The map should contain the clearly marked location of the monitoring site, latitude and longitude markers, and the watershed contributing flows to the site. The electronic map document should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2001-2002 or 01-02) to which it corresponds.

3.29. Photograph

Field Type: Text
Field Size: 50 characters
Example: Site 7-21 Photo_2001-2002.jpeg
Definition: The name of the electronic document containing photograph(s) of the monitoring site.
Notes: The actual electronic document containing photograph(s) of the monitoring site should be submitted along with the rest of the data collected for the site, including water quality data, time series data, and a map. The electronic photograph document should be labeled with the Caltrans Monitoring Site ID and monitoring season (e.g., 2001-2002 or 01-02) to which it corresponds.

3.30. Site Notes

Field Type:	Text
Field Size:	255 characters
Example:	No AADT value provided for this site. Site is located along a county road for which no AADT data are available.
Definition:	This data field contains any notes or remarks about the monitoring site or various data fields used to describe the monitoring site.
Notes:	Data reporter should provide a note for any data field left blank. It is not appropriate to provide a note in a particular cell of a data field other than Site Notes. Considering the example above, it is not appropriate to place the note, "No AADT value provided for this site. Site is located along a county road for which no AADT data are available", in the AADT data field. The note must be entered into the Site Notes data field.

4. AQUATIC TOXICITY SAMPLE DESCRIPTIONS

4.1 Event ID

Field Type: Text
Field Size: 8 characters
Example: 2001-01
Definition: A unique, site-specific identification number assigned to a sampling event.
Notes: Event ID follows the format "Year monitoring season begins-Number of event at site beginning with 01". The first event at any site would be assigned an Event ID of "Year-01". Additional events at a particular site shall be numbered consecutively beginning with "Year-02". Even if a site isn't monitored until the latter half of the monitoring season (e.g., Site X is monitored during Feb. – Apr. 2002 – the latter half of the 2001-2002 monitoring season), its Event IDs include the year in which the general Caltrans monitoring season began (e.g., samples collected during the first event at Site X in Feb. 2002 are assigned Event IDs of "2001-01").

4.2 Monitoring Site ID

Field Type: Text
Field Size: 8 characters
Example: 7-21
Definition: A unique identification number assigned to the monitoring site by Caltrans.
Notes: The first part of the Monitoring Site ID corresponds to the Caltrans district in which the site is located.

4.3 Field Sample ID

Field Type: Text
Field Size: 35 characters
Example: 134-0010-281500A
Definition: Field identification number assigned to sample/sample vessel.
Notes: This data field can contain any combination of text and numeric characters.

4.4 Sample Start Date

Field Type: Date
Field Size: n/a
Example: 11/05/2001
Definition: Date on which composite sampling begins or grab sample is collected. In regard to composite samples, specifically the date on which the sampler was activated <u>and</u> the flow meter began totalizing flow.
Notes: Formatted as mm/dd/yyyy.

4.5 Sample Start Time

Field Type: Time
Field Size: n/a
Example: 15:24
Definition: Time at which composite sampling begins or grab sample is collected. In regard to composite sampling, specifically the time at which the sampler was activated and the flow meter began totalizing flow.
Notes: Formatted for 24-hour clock (hh:mm).

4.6 Sample End Date

Field Type: Date
Field Size: n/a
Example: 11/05/2001
Definition: Date on which composite sampling ends. Specifically, the date on which the sampler was de-activated and the flow meter stopped totalizing flow.
Notes: Formatted as mm/dd/yyyy.

4.7 Sample End Time

Field Type: Time
Field Size: n/a
Example: 15:24
Definition: Time at which composite sampling ends. Specifically, the time at which the sampler was de-activated and the flow meter stopped totalizing flow.
Notes: Formatted for 24-hour clock (hh:mm).

4.8 Sample Source

Field Type: Text
Field Size: 12 characters
Example: Storm
Definition: Identifies the source of the water quality sample analyzed.
Notes: Standardized Entry. Enter value from standard list or contact database manager.

Standard List

- Storm - Sample from storm water runoff
- Rain - Sample from rainwater
- Receiving - Sample from receiving water
- Vadose - Sample from vadose zone
- Base - Sample from dry-weather base flow
- Groundwater - Sample from groundwater
- Non-storm - Sample from non-storm water runoff
- BMP media - Sample from material used to construct BMP device

4.9 Event Representation

Field Type: Text
Field Size: 12 characters
Example: FF
Definition: Describes the part of the event represented by the sample.
Notes: Standardized Entry. Enter value from standard list or contact database manager.
Standard List

- FF - Event first flush
- Peak - Event peak flow
- Whole - Whole storm
- Discrete - One or more discrete samples collected during an event that cannot be described as representing the first flush, peak or whole storm portion of the event. This value will typically, although not exclusively, be used for a "Non-storm" Sample Source.
- X-hr Comp - Used to describe a planned composite sampling event lasting X hours.

4.10 Sample Type

Field Type: Text
Field Size: 2 characters
Example: C
Definition: Describes the way in which sample was collected.
Notes: Standardized Entry. Enter value from standard list or contact database manager.
Standard List

- C - Composite Sample: A sample made up of multiple sub-samples (aliquots) collected over some spatial or temporal scale.
- G - Grab Sample: A single sample that represents conditions at a distinct point in time.

4.11 Sample Matrix

Field Type: Text
Field Size: 10 characters
Example: Water
Definition: Matrix from which sample was analyzed.
Notes: Standardized Entry. Enter value from standard list or contact database manager.
Standard List

- Water
- Sediment (not currently included in Caltrans toxicity protocols).

4.12 Collection Method

Field Type: Text
Field Size: 6 characters
Example: Auto
Definition: Describes the way in which a sample was collected.
Notes: Standardized Entry. Select value from standard list or contact database manager.
Standard List

- Auto - Sample aliquot collected by automated sampling device.
- Manual - Sample aliquot collected manually.

4.13 Treatment

Field Type: Text
Field Size: 30 characters
Example: 100 ppb PBO
Definition: Description of any treatment (manipulation or chemical addition) to the original runoff sample.
Notes: This data field is only to include simple and/or targeted manipulations of the sample (chemical spikes, aeration, pH adjustments, etc.) and is not intended to incorporate all sample manipulations that may be included in a full TIE.

4.14 Test Type

Field Type: Text
Field Size: 18 characters
Example: Acute, screen
Definition: Designates if the test was an acute or chronic test and if the test was a screening level test or a full dilution series test.
Notes: Standardized entry.
Standard List

- Acute, screen
- Acute, dilutions
- Chronic, screen
- Chronic, dilutions

4.15 Test Start Date

Field Type: Date
Field Size: n/a
Example: 02/22/2001
Definition: Date on which the toxicity test is initiated.
Notes: Formatted as mm/dd/yyyy

4.16 Test Start Time

Field Type: Time
Field Size: n/a
Example: 14:25
Definition: Time at which toxicity test is initiated.
Notes: Formatted for 24-hour clock (hh:mm)

4.17 Test End Date

Field Type: Date
Field Size: n/a
Example: 02/24/01
Definition: Date toxicity test is completed.
Notes: Formatted as mm/dd/yyyy

4.18 Test End Time

Field Type: Time
Field Size: n/a
Example: 14:30
Definition: Time at which test is terminated.
Notes: Formatted for 24-hour clock (hh:mm)

4.19 Test Organism

Field Type: Text
Field Size: 25 characters
Example: *Ceriodaphnia dubia*
Definition: Identify species tested.
Notes: Use scientific name (e.g. *Pimephales promelas* for fathead minnow)

<u>Standard List</u>

- *Ceriodaphnia dubia*
- *Pimephales promelas*
- *Selenastrum capricornutum (changed to Raphidocelis subcapitata)*
- *Oncorhynchus mykiss*

4.20 Toxicity Endpoint

Field Type: Text
Field Size: 20 characters
Examples: Mortality
Definition: Provide the endpoint tested in a given toxicity test.
Notes: Standardized entry, see standard list. Use endpoints associated with the appropriate species and test type as indicated in Table 1 of the general instructions section. Consideration of screening level or dilution series tests is not required for this data field.

Standard List

- Mortality
- Reproduction
- Growth
- Growth (cell number)

4.21 Result Type

Field Type: Text
Field Size: 12 characters
Examples: Significance
Definition: Expression of the endpoint measured.
Notes: Standardized entry, see standard list. Use result types associated with the appropriate endpoints and test type as indicated in Table 1 of the general instructions section. Note that screening level and dilution series tests will provide different result types as indicated in the standard list.

Standard List

- Mean mortality
- Statistically significant difference from control
- Standard error
- LC50
- LC25
- LC10
- EC50
- EC25
- EC10
- IC50
- IC25
- IC10
- NOEC
- LOEC
- Chronic Toxic Units
- Mean reproduction
- Mean growth

4.22 Units

Field Type: Text
Field Size: 15 characters
Example: %
Definition: Describes units of reported result.
Notes: Standardized entry, see list below. Also see Table 1.

Standard List	Example
• %	-percent mortality
• yes/no	-statistical significant difference (answer either yes or no)
• neonates/adult	-C.dubia reproduction
• mg/individual	-growth
• cells/mL	-algal growth
• % dilution	-only used if a dilution series was run
• TUa	-acute toxic unit= LC50, etc. divided by the highest tested concentration
• TUc	-chronic toxic unit=NOEC, etc. divided by highest tested concentration

4.23 Numerical Qualifier

Field Type: Text
Field Size: 1 character
Example: <
Definition: An indication of what the value represents (i.e. a minimum, maximum, or "exact" value).
Notes: Standardized entry. Enter name from standard list or notify database manager.

Standard List

- < -actual value is less than the reported value (non-detect) ADD
- = -value is as reported.
- > -actual value is greater than reported value.

4.24 Result

Field Type: Numeric
Field Size: n/a
Example: 30
Definition: Reported test result (30% mortality).
Notes: Standardized entry.

4.25 Statistical Significance (Statsig)

Field Type: Text
Field Size: 3 characters
Example: Yes
Definition: To indicated if there was a significant difference between the runoff sample result and the control result.
Notes: Standardized entry, see standard list.

Standard List

- Yes
- No

4.26 Test Day

Field Type: Numeric
Field Size: Provide number as an integer with zero (0) decimal places.
Example: 7
Definition: Indicates the day of a multi-day test. For example, the first 24 hours (0-24 hours) of the test is referred to as day 1, 24-48 hours as day 2, etc.
Notes: Formatted as a whole number, do not use hours (48 hrs = 2 days).

4.27 TIE Performed

Field Type: Text
Field Size: 3 characters
Example: Yes
Definition: Indicates if TIE manipulations are associated with this sample.
Notes: Standardized entry, see standard list

Standard List

- Yes
- No

4.28 Suspect Toxicant

Field Type: Text
Field Size: 50 characters
Example: Diazinon
Definition: Indicates if a specific toxicant or toxicants were identified using TIE methods.
Notes: List constituent(s) identified as toxicant(s). List class of compound (metals) if specific constituent was not identified. If neither the class nor specific constituent were identified list "none". See standard list for compound classes.

Standard List

- Metals
- Non-polar organics
- Volatiles
- Oxidants
- pH dependent
- Polar organics
- Anionic inorganic

4.29 TIE Phase completed

Field Type: Numeric
Field Size: 1 characters
Example: 2
Definition: TIEs are conducted in a series of phases, 1-3. This data field identifies which phases were completed.
Notes: Standardized entry. See standard list.

Standard List

- 1
- 2
- 3

4.30 Control ID

Field Type: Text
Field Size: 35 characters
Example: Lab-001-QA
Definition: Identifies the laboratory control associated with the sample.
Notes: Standardized entry.

4.31 Lab Name

Field Type: Text
Field Size: 25 characters
Example: APPL
Definition: Name of laboratory that analyzed sample.
Notes: Standardized Entry. Select value from standard list. The list of analytical laboratories used by the Caltrans Storm Water Management Program will likely change over time, and therefore the Standard List below might not include the name of every laboratory used in any given monitoring year.

Standard List

- Aquascience
- Aquatic Bioassay and Consulting (ABC) Laboratory
- Associated Labs
- BSK
- CEL - Calscience Environmental Labs
- Del Mar Analytic
- GeoAnalytical Labs
- North Coast Labs
- Pat-Chem
- Quanterra
- Silliker
- Soil Control Lab
- ToxScan
- UCDATL -UC Davis Aquatic Toxicity Lab

4.32 Lab Sample ID

Field Type: Text
Field Size: 25 characters
Example: 120085-400A
Definition: Laboratory identification number assigned to sample by analytical laboratory.
Notes: This data field can contain any combination of text and numeric characters.

4.33 Contract Number

Field Type: Text
Field Size: 12 characters
Example: 43A005
Definition: Caltrans contract number under which sample was collected.
Notes: This data field can contain any combination of text and numeric characters.

4.34 Task Order Number

Field Type: Text
Field Size: 6 characters
Example: 11
Definition: Caltrans task order number under which sample was collected.
Notes: This data field can contain any combination of text and numeric characters.

4.35 Toxicity Notes

Field Type: Text
Field Size: 255 characters
Example: Statistically significant toxicity was not observed, but sublethal effects (behavior or physical defects) were observed.
Definition: This data field contains any notes or remarks about the toxicity sample or various data fields used to describe the toxicity sample.
Notes: Data reporter should provide a note for any data field left blank (with the exception of Overall Qualifier and Statistical Significance). It is not appropriate to provide a note in a particular cell of a data field other than Toxicity Notes. Considering the example above, it is not appropriate to place the note, "Sublethal effects including changes in behavior and physical defects were observed", in the Result Type data field. The note must be entered into the Toxcity Notes data field.