Chapter 5
IMPLEMENTATION OF MONITORING PLAN

Proper implementation of a monitoring plan is as important as a well-designed plan. This chapter provides some general guidance on considerations and activities that can help implementation of a monitoring plan go more smoothly. Some factors considered are training of personnel, installation of equipment, and the mobilization and coordination with the laboratory.

5.1 Training of Personnel

Each member of the monitoring team must receive whatever training is necessary to properly perform his or her assigned roles. Generally, the first step is for each team member (including back-up personnel) to review the monitoring plan and health and safety plan. Next, the team members attend an initial orientation session that includes a "dry run" during which team members travel to their assigned stations and simulate monitoring, sample documentation, packaging, and so on. This all takes place under the supervision of the instructor (usually the principal author of the monitoring plan). Health and safety precautions should be reinforced during the dry run, along with QA/QC procedures. Periodic "refresher" orientation sessions should be conducted after long dry periods, or when the monitoring team composition changes. Typical components of a health and safety plan are provided in Exhibit 5-1. Exhibit 5-2 provides an initial list of resources that can be helpful in developing a health and safety plan (which is part of developing a monitoring plan that is discussed in Chapter 2), as well as educating those conducting sampling on key safety issues.

Exhibit 5-1. Representative Topics for Inclusion in a Health and Safety Plan
(Source: Caltrans 2000,
http://www.dot.ca.gov/hq/env/stormwater/special/guidance_manual/)

1.0 Introduction	7.0 Site-Specific Health And Safety Requirements
2.0 Project And Safety Personnel	7.1 Special Medical Tests
3.0 Site Information	7.2 Special Training
4.0 Work Activities Covered By Health And Safety Plan	7.3 Physical Hazards
5.0 Hazard Assessment	7.4 Hazardous Materials Identification & Protection
5.1 Chemical Hazards	7.5 Confined Space Entry
5.2 Confined Spaces	7.6 Traffic Control
5.3 Physical Hazards	7.7 Personal Protective Equipment
5.4 Biological Hazards	7.8 Site Illumination
6.0 General Health And Safety Requirements	7.9 Biological Hazard
6.1 Employee Clearance	8.0 Emergency Response Procedures
6.2 Site Safety Meetings	8.1 Hospital Information
6.3 Accident Reporting	8.2 Emergency Route to Hospital
6.4 Prohibited On-Site Activities	8.3 First Aid & Related Equipment
6.5 Communications	

Exhibit 5-2. Supplemental Health and Safety References

Centers for Disease Control and Prevention. http://www.cdc.gov/

EPA. 1992. *National Pollutant Discharge Elimination System Storm Water Sampling Guidance Document.* EPA 833-8-92-001. See Chapter 6. http://www.epa.gov/npdes/pubs/owm0093.pdf

Federal Highway Administration (FHWA). Appendix B. *Example Health and Safety Plan*. http://www.fhwa.dot.gov/environment/h2o_runoff/h2oroapb.htm

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U.S. Department of Labor Occupational Safety and Health Administration. http://www.osha.gov/

U.S. Geological Survey Memo SW 05.03. *Interim Plan for Accessing Confined-Space Stilling Wells.* http://water.usgs.gov/admin/memo/SW/sw05.03.html

U.S. Geological Survey Memo WRD 99.32. *Water Resources Division Policy for Safety Associated with Measurements, Sampling, and Related Streamgaging.* http://water.usgs.gov/admin/memo/policy/wrdpolicy99.32.html

U.S. Geological Survey Memo WRD 99.01. *SAFETY-Traffic Control Plan for Field Operations from Bridges and along Roadways.* http://water.usgs.gov/admin/memo/policy/wrdpolicy99.01.html

U.S. Geological Survey Water Resources Division Immunization Program. http://water.usgs.gov/admin/memo/policy/wrdpolicy96.29.html

5.2 Installation of Equipment

If automated monitoring methods are used, then sampling and flow measurement equipment must be installed following manufacturer's instructions. Equipment installation procedures vary depending on the specific equipment and the configuration of the monitoring location. Some general recommendations for equipment installation are listed below:

- Personnel must follow the health and safety plan when installing equipment. Some monitoring locations may require use of protective clothing, traffic control, combustible gas meters, and special training in confined space entry procedures.

- Bubbler tubes, pressure transducers, and velocity sensors typically are mounted on the bottom of the channel in the middle of the channel cross-section, facing upstream. Ultrasonic depth sensors typically are mounted above the water surface.

- Automated sampler intake tubing should be mounted in a way that the tubing and intake do not interfere with the flow measurement device. Typically, the intake will be fitted with a strainer to prevent clogging.

- Probes, sensors, and intake lines usually are anchored to the pipe or channel. The intake tubing should be anchored throughout its length so that it will not bend, twist, or crimp under high flows. Often, it is advisable to route intake tubing through a conduit from the channel to the sampler housing to protect the tubes and lines from gnawing animals or from being crushed. For a well coordinated monitoring effort, it may be possible to install conduits in conjunction with construction of the Best Management Practice (BMP).

- Weirs and flumes must be secured to the bottom of the pipe or channel. If the monitoring location is in a swale, the weir or flume cutoff walls must be buried in each bank so that the structure extends all the way across the channel and all flow is directed through the weir or flume.

- If not installed inside a manhole vault, the flow meter and automated sampler should be placed in a sturdy shelter to protect the equipment from vandalism and other damage.

- If batteries are used as the power supply, fresh batteries should be installed at the frequency recommended by the manufacturer or before each anticipated storm monitoring event.

It is helpful to have a field equipment preparation checklist (see Exhibit 5-3 below) to ensure that appropriate equipment is available and in good condition. A field box should contain tools, spare parts, operation manuals for equipment, copies of the Monitoring Plan and Monitoring Checklist, safety equipment, and other supplies that might be useful during sample collection and transport. The field equipment box should be checked approximately 24 hours prior to the anticipated monitoring to ensure all equipment is included and in good condition.

Exhibit 5-3. Example Field Equipment Preparation Checklist

Documentation	Safety
Health and Safety Plan Stormwater Monitoring Plan Monitoring Plan checklists and field notebooks Equipment manuals Chain-of-custody forms/bottle labels/permanent markers/pen/pencils	Portable gas monitor (in one box only) Safety line Tripod, winch, and safety harness (1 per vehicle) Flashing lights for vehicle Traffic cones Cell phone (or two way radios) Flashlights (1 per person) Gloves (protective leather and nitrile) Hard hat (1 per person) Goggles (1 set per person)
Sampler	
Graduated cylinder for sampler calibration Spare suction line (0.24-in to 0.375-in diameter) Spare strainer Spare battery Masonry anchors & screws Masonry drill bits Tubing anchors or galvanized steel strapping	**Miscellaneous**
Flowmeter	Battery powered drill Hand tools (hammer, screwdriver, pliers, knife, hacksaw, wire strippers, measuring tape) Manhole hook Buckets Ropes Duct tape Distilled water Watch or stopwatch Digital camera Heavy duty hand truck Cash and credit card
Depth-measuring rod Data interrogator or laptop computer Spare batteries Area velocity sensor Cable ties Calibration equipment (see flowmeter manual)	

5.3 Testing and Calibrating Equipment

Water quality probes (e.g., pH, conductivity), automated samplers, and flow meters must be periodically calibrated in order to ensure reliable operation and credible results. Typical calibration procedures are summarized in this section; however, always follow the manufacturer's instructions when calibrating a specific monitoring device.

Calibration of pH meters, conductivity meters, dissolved oxygen meters, and other water quality instruments generally involves two steps:

1) Use the instrument to measure a known standard and determine how much the instrument's measurement differs from the standard.

2) Adjust the instrument according to the manufacturer's instructions until it provides an accurate measurement of the standard.

Automated sampling equipment should be calibrated after installation to ensure it pumps the correct volume of sample. The condition of the sampler pump and intake tubing, the vertical distance over which the sample must be lifted, and other factors can affect the volume drawn. Therefore, test the sampler after installation and adjust the sampler programming if necessary to be sure the system consistently draws the correct sample volume. For an extra level of assurance, installed equipment should also be calibrated prior to storm events, where feasible. It is important that the monitoring team understand the automated sample trigger conditions and the sampler program settings to ensure that the samples are being collected at the appropriate intervals along the hydrograph. A mock monitoring event, even for automated samplers, can be beneficial to ensure that sample collection is being triggered correctly.

Flow meters can be affected by the hydraulic environment in which they are placed; consequently, they should be calibrated after installation to ensure accuracy. Because sediments, debris, and other materials carried by stormwater can damage or clog bubbler tubes and pressure transducers used for depth measurements, they must be frequently inspected and calibrated by checking the flow depth with a yard stick or staff gage. Ultrasonic velocity sensors and other instruments that measure flow rate must also be inspected and checked against velocity measurements using a current meter.

5.4 Conducting Monitoring

After completing the preparations described above, manual or automated monitoring can be initiated for the storm events. Manual monitoring requires an increased level of staff effort to prepare for the storm. (Flow monitoring and water quality sample collection techniques are discussed in Chapters 3 and 4, respectively.)

The general steps for manual monitoring are:

1) The monitoring team leader or another designated person tracks the weather forecasts. For manual monitoring, a vigilant "weather watch" is critical in order to reach the site in time to monitor the initial runoff from a storm event and coordinate the monitoring team, pick-up ice, notify the laboratory, and so on. A close weather watch can also help avoid wasting time with "false starts" when a forecasted storm fails to materialize. Exhibit 5-4 provides a representative weather tracking protocol that can help this process go more smoothly.

2) When the weather forecasts indicate that a potentially acceptable storm is approaching, the monitoring team leader contacts the monitoring team and the analytical laboratory. If any of the primary team members are unavailable, the monitoring team leader arranges for back-ups. The team members check their instructions, communications protocols, monitoring equipment, and supplies to ensure they are ready.

3) The monitoring team leader contacts National Oceanic and Atmospheric Administration (NOAA), or some other meteorological service if better information is

available, to get updated forecasts as the storm approaches. When the forecasts indicate that the storm is likely to start within the next few hours, and it still appears likely to meet the storm selection criteria, the team leader directs the team members to proceed to their assigned monitoring stations so that they arrive before the predicted start time. The team leader also alerts the lab that samples are likely to be delivered soon.

4) The team members travel to their assigned locations and start collecting samples and taking flow measurements as soon as possible after stormwater runoff begins. The team completes the sample labels, chain-of-custody forms, and other field documentation.

5) During monitoring, team members in the field should be able to contact the team leader by cell phone to ask questions, notify him or her of changing conditions, receive direction, and so on. Additionally, for safety reasons, an expected return time and/or check-in time should be established (e.g., if the team has not returned or checked in within an expected timeframe, then someone needs to follow-up to ensure that the team is safe).

6) After the samples have been collected, ship or deliver the samples to the analytical laboratory, being sure to comply with temperature and holding time requirements specified in the sampling plan.

7) Normally, field personnel prepare all samples, including composting, filtering and preserving, prior to shipping to the laboratory.

8)

Exhibit 5-4. Example Standard Operating Procedure for Weather Tracking and Monitoring Preparation

The Storm Event Coordinator will review the daily National Weather Service forecasts (http://www.nws.noaa.gov) and track all potential rainfall events. If an event being tracked has a 75 percent or greater probability of generating 0.2 inches of rainfall within a 24 hour period, the Storm Event Coordinator will inform the Monitoring Team 72 hours before its predicted arrival and the Team will be placed in a "Prepare Mode".

Monitoring Team "Prepare Mode"

- Order bottles from lab and alert lab of possible monitoring activities (may want to keep a supply on hand during monitoring season)
- Assemble field equipment
- Arrange team members schedule for field activities
- Arrange vehicle for monitoring activities
- For first event of each season, check and flag all sample locations and assess site conditions, report any potential problems to Storm Event Coordinator

The Storm Event Coordinator will maintain frequent contact with the Weather Service and if the forecast still predicts a target magnitude event at 48 hours before its arrival, the Monitoring Team will be placed in a "Stand-By Mode".

Monitoring Team "Stand-By Mode"

- Identify Monitoring Team and arrange schedules for field activities
- Check bottle inventory against station check list
- Initiate chain of custody procedure
- Bench test and calibrate all field equipment
- Confirm team member schedules for field activities
- Arrange for vehicle to conduct monitoring activities

At 24 hours before the event is predicted to arrive if there is still a 75 percent probability that the storm will generate 0.2 inches of rainfall within 24 hours, the Storm Event Coordinator will receive Quantitative Precipitation Forecasts (QPF) every 6 hours (or more frequently) from the Weather Service and a monitoring "Alert" will be issued.

Monitoring Team "Alert Mode"

- Label bottles
- Check field boxes for supplies
- Ensure a sufficient amount of ice for sampling and sample transport
- Set up sampling equipment at sites (preferably during daylight hours)

(Continued on next page)

Exhibit 5-4 *(continued)*. Example Standard Operating Procedure for Weather Tracking and Monitoring Preparation

At 12 hours before a target event is scheduled to arrive, a Go/No-Go decision on monitoring will be made by the Storm Event Coordinator. The latest QPF will be obtained from the Weather Service and sampler programming calculations will be done for each site; this information will be relayed to the Monitoring Team.

Monitoring Team "Go"

- Mobilize Monitoring Team
- Install fully charged batteries in samplers
- Program automated samplers
- Install clean bottles in samplers
- Check all tubing, connections, and strainer placement

Monitoring Team "No-Go"

- Retrieve sampling equipment
- Inventory, clean, organize, and prepare sampling equipment for next event

Once precipitation has begun, the Monitoring Team will go into "Sample Mode"

Monitoring Team "Sample Mode"

- Contact Storm Event Coordinator and confirm "Go" decision
- Place ice in automated samplers
- Follow site specific sampling plan or operating procedures

The general steps for automated monitoring are:

1) Perform routine inspection and maintenance to help ensure that the equipment will function properly when a storm event occurs.

2) Keep track of precipitation. After each storm, check the local rainfall records (or preferably a rain gage at or near the center of the basin) to see if the amount of precipitation and the antecedent dry period met your pre-determined criteria.

   - If the storm did not meet sampling plan criteria, remove the sample bottles from the sampler and replace them with clean bottles. Empty the sample bottles and arrange for them to be cleaned.

   - If the storm criteria were met, remove the sample bottles. Check them to be sure they collected the proper amount of sample. Check the sampling times against the storm duration to see how much of the storm was sampled (e.g., what portion of

the hydrograph was captured). If sampling criteria were met, complete the sample labels, chain-of-custody forms, and other field documentation, then deliver the samples to the laboratory for analysis.

3) If the sampler overfilled or underfilled the sample bottles, refine the sampler programming.

4) Reset the sampler and inspect all of its systems for possible damage or clogging so that it will be ready to sample the next storm.

5.5 Coordinate Laboratory Analysis

Most stormwater monitoring programs involve laboratory analysis. Exceptions include: (1) field screening programs that rely solely on visual observations and field test kits; and (2) programs that rely on "in-situ" monitoring of indicator parameters (e.g., pH, dissolved oxygen, turbidity) using probes and data loggers.

It is a good idea to involve laboratory personnel in identifying the analytical methods and establishing communications protocols and QA/QC protocols. Typically, the laboratory will provide the pre-cleaned sample bottles and distilled/deionized water used for monitoring. Exhibit 5-5 provides guidance on proper bottle organization.

Exhibit 5-5. Bottle Organization Procedures

1) Bottles of proper size and material and sufficient quantity should be prepared by the analytical lab and delivered to the Monitoring Team at least 48 hours prior to the sampling event (see sample bottle order form). Bottles should be inventoried and checked against the site specific operating procedures for each monitoring station.
2) A separate 80-quart Rubbermaid Environmental Cooler should be prepared and clearly labeled for each set of samples at each monitoring station. The cooler should include the required bottles for sampling at that site as well as bottles for blanks and duplicates as required by QA/QC plan.
3) All sample bottles should be labeled prior to placement in sampler and as much information as possible should be filled out on the labels when bottles are dry. A second label or corresponding Sample ID No. should be place on sample bottle lid.
4) One set of clean beakers in Ziploc bags (1-250 ml and 1-500 ml) should be placed in coolers with bottles.
5) Powder-free nitrile gloves should be worn whenever handling clean bottles.

Sample Site Identification Information

Site Name	Site ID Number	Grab Sample Bottles	Automated Sample Bottles

Mobilization protocols should include notifying the laboratory when a storm monitoring event appears imminent. It is also good practice to contact the laboratory shortly after the monitoring event to ensure that the samples were received in good condition and to answer any questions the lab may have regarding the analyses to be conducted. Frequent communication with the laboratory helps reduce the risk of incorrect analysis and other potential unpleasant "surprises."

An essential aspect of strong coordination with the laboratory is proper completion of the chain-of-custody form provided by the laboratory. The chain-of-custody form is a legal document designed to track samples and persons who are responsible for them during preparation of the sample container, sample collection, sample delivery, and sample analysis. The chain-of-custody form must be filled out correctly and completely to minimize errors during the analytical process. Be sure to retain a copy of the completed chain-of-custody document and keep it accessible to answer questions that may arise from the laboratory.

General guidance for transporting, packing and transporting samples from the field to the laboratory include:

1) Clearly mark the analyses to be performed for each sample.

2) Fold the field-sampling sheets and chain-of-custody form and place them in plastic bags to protect the sheets during transport. Tape chain-of-custody form to the lid of the cooler.

3) Pack samples well to prevent breakage or leakage (samples should already be labeled) and provide additional protection for glass sample bottles (e.g., foam or bubble wrapping).

4) Sample should be packed in ice or an ice substitute to maintain a sample temperature of 4° C during shipping. Ice (or substitute) should be placed in double wrapped watertight bags to prevent leaking during shipping.

5) Using duct tape or packing tape, wrap the cooler twice to seal the opening.

6) On the sealing tape, write the date and time the sample container was sealed

7) Affix destination, identification, and FRAGILE labels to each shipping container.

8) Samples must be delivered to the analytical laboratory within maximum hold times. (For example, if bacteria samples are collected, delivery should be within 4 hours of sampling to ensure the 6-hour maximum holding time for bacteria is not exceeded.)

5.6 Conclusion

Effective implementation of the monitoring plan is a fundamental component of a successful BMP monitoring program. Careful attention to equipment installation and calibration, proper sampling techniques and handling, as well as strong coordination with the laboratory conducting the analysis is key to a properly implemented monitoring program. It is essential

that the staff involved in implementation of the monitoring program be properly trained to conduct these tasks.

5.7 References

Caltrans. 2000. *Guidance Manual: Stormwater Monitoring Protocols – July 2000*. http://www.dot.ca.gov/hq/env/stormwater/special/guidance_manual/

Centers for Disease Control and Prevention. http://www.cdc.gov/

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