Citizen Volunteer Scientist Participation in Monitoring Stormwater Discharges in NH Seacoast Municipalities

Chapter 3
COMPREHENSIVE MONITORING PLAN:
Volunteer Storm Drain Monitoring in New Hampshire

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Dr. Stephen Jones
Research Associate Professor of Marine Biology and Natural Resources
Dept. of Natural Resources and the Environment
University of New Hampshire
Jackson Estuarine Laboratory
85 Adams Point Rd
Durham, NH 03824

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PURPOSE

This document is intended to provide guidance for small municipalities interested in designing a monitoring plan for storm drain discharges and their impacts on receiving waters.

INTRODUCTION & GOALS

While threats to water quality and both ecosystem and public health continue to increase, resources to help monitor the environment, mitigate problems and restore natural resources are becoming more limited. Fortunately there is an increasing interest by New Hampshire citizens to become involved in activities that help address these issues on a volunteer basis. To maximize beneficial outcomes, these efforts are best conducted when there is coordination with environmental agencies, scientists and local towns, and especially where effort is made to harmonize approaches to produce compatible results across regional efforts so management actions and resources can be focused in the most effective ways to address problems.

The impacts of stormwater runoff on water quality in the New Hampshire Seacoast region have been acknowledged (UNH-SC 2011) and well documented (Jones and Langan, 1996) for quite some time, yet coordinated efforts to manage this issue have not yet fully evolved. This monitoring plan addresses a small but important and timely piece of this issue: storm drain monitoring by volunteers in collaboration with small municipalities. Storm drains represent a largely uncharacterized, yet potentially significant (see Chapter 1, this study) source of pollution that will require substantial effort to adequately monitor. Monitoring will be an integral part of upcoming MS4 permit requirements for small municipalities, as it is now for larger cities. This plan is based on a recent pilot project involving local volunteers in two towns in New Hampshire's Seacoast region, Greenland and Exeter (see Chapters 1 & 2, this study). Key partners included the NH Sea Grant's Coastal Research Volunteer (CRV) Program, town officials, local river advisory boards and monitoring programs, and NHDES through the Coastal Program and the Volunteer River Assessment Program (VRAP). There are many other potential partnership organizations that work in areas related to storm drain monitoring (Table 1).

Acronym	Organization	Function*	Website
CRV	Coastal Research Volunteer Program	V,M,S,E	http://www.seagrant.unh.edu/crv.html
NHSG	NH Sea Grant Program	V,C,E,X	http://www.seagrant.unh.edu/
NHCP	NH Coastal Program	C,E	http://des.nh.gov/organization/divisions/water/wmb/coastal/
VRAP	Volunteer River Assessment Program	V,M,S	http://des.nh.gov/organization/divisions/water/wmb/vrap/index.htm
UNH-JEL	Jackson Estuarine Lab	M,S,A	http://marine.unh.edu/jel/home.htm
UNH-WQAL	Water Quality Analysis lab	A,S,M	http://www.wrrc.unh.edu/lab/facilities.html
UNH-SC	Stormwater Center	M,S,C,E	http://www.unh.edu/unhsc/
NHDES	NH Department of Environmental Services	M,S,A,C,E	http://des.nh.gov/organization/commissioner/lsu/index.htm
PREP	Piscataqua Region Estuaries Partnership	C,E,S	http://prep.unh.edu/
GBNERR	Great Bay National Estuarine Research Reserve	M,S,C,E	http://www.greatbay.org/
WRWC	Winnicut River Watershed Coalition	V,M,S,E,C	http://www.winnicutcoalition.org/
ERLAC	Exeter River Local Advisory Committee	V,M,E	http://www.exeterriver.org/
CRWC	Cocheco River Watershed Coalition	V,M,E	
LRWA	Lamprey River Watershed Association	V,M,E,C	http://www.lrwa-nh.org/
ORWA	Oyster River Watershed Association	V,M,E	http://www.lefh.net/orwa/
SWA	Southeast Watershed Alliance	S,C,E	http://southeastwatershedalliance.org/
SSC	Seacoast Stormwater Coalition	S,M,C,E	http://des.nh.gov/organization/divisions/water/stormwater/video_towns_list.htm

*A=Analysis, C=Communication, E=Education/Outreach, M=Monitoring, S=Scientific expertise, V=Volunteers, X=Extension

Table 1. Potential partner organizations for volunteer storm drain monitoring.

The main sections of this monitoring program include planning, implementation and application of findings. The planning stage requires coordination of local, state and scientific expert participants to maximize the effective use of limited resources and the broadest use of the findings. Volunteers require training and clearly stated instruction to ensure their safety and that quality data are produced. The results should be designed to inform local towns about which storm drains are significant pollution sources and thus require further action to reduce impairments in receiving waters. End users should be engaged from the start, and the monitoring program should be designed to serve follow-up actions to eliminate pollution sources and implement best management practices. A final, critically important part of the plan is the educational value of volunteer participation. Volunteers who participate in the monitoring can gain valuable, direct experience with scientific methods and field sampling logistics, while the results can be used to help build local stewardship of the natural resources in peoples' backyards.

PLANNING PROCESS

Participant recruitment and coordination

The management of storm drains as pollution sources is most effectively conducted at the level of municipalities. One challenge is cost, especially for small municipalities where the town infrastructure may not include expertise or the personnel/time to adequately address this issue. Outside help is often required, however, resource availability is often limited. The EPA's

NPDES-MS4 program offers information about potential funding sources and strategies on their web page: http://cfpub.epa.gov/npdes/stormwater/munic.cfm.

One largely untapped resource in towns is volunteers. One important benefit of engaging volunteers as part of a monitoring program is their time and costs are donated, and can be used as matching funds to leverage core program support. Engagement of volunteers still requires expert oversight, yet the capacity for meeting the time and coverage commitments required for tasks like monitoring storm drains can be met with volunteers at significantly reduced overall costs. The NH Seacoast region has abundant interested citizens and expertise for addressing environmental issues through collaborative efforts between towns, volunteers and scientists. At present, there is no existing entity that brings those elements together for adoption by small municipalities to assess storm drains as pollution sources, and the various elements exist as separate entities. Some towns have organized through the NH Seacoast Stormwater Coalition (Table 1) to help coordinate their approach for addressing stormwater issues, and the Southeast Watershed Alliance has also been involved in helping to coordinate regional needs by establishing model stormwater standards for NH coastal watershed communities (SWA 2012).

Towns need to coordinate overall stormwater management plans that, besides storm drain monitoring, include many more elements like BMP implementation, public outreach and education. Because storm drains are located throughout urbanized areas, town officials need to help volunteers gain access to these locations and provide permission to cross private property where that is necessary. The data and interpretation of findings generated from volunteer storm drain monitoring can be used by towns to instigate follow-up management actions, so their role is also to ensure monitoring is conducted in a fashion to best suit their local needs.

The relatively new (2011 to present) CRV Program (Table 1) has organized volunteers and their training/coordination to address scientific issues in the NH Seacoast region. The CRV program has successfully recruited and collaborated with local volunteers in two Seacoast towns to monitor and assess storm drains as pollution sources to receiving waters. These collaborations have helped to both engage local volunteers and to compliment ongoing efforts to assess and protect the quality of surface waters. The CRV Program works with a variety of different researchers and state agencies as an organized volunteer program to help accomplish more environmental research in the NH Seacoast and to provide meaningful learning experiences for volunteers. The CRV program will continue in this role as it gains experience in different scientific and monitoring projects that address the most pressing local environmental issues.

To understand what pollutants are present and at what levels, water from storm drains requires quality-assured measurements and professional analysis. The University of New Hampshire has several research labs that are involved in these capacities as part of research studies and monitoring programs in the NH Seacoast. The Jackson Estuarine Laboratory (JEL) has resident expertise in a wide range of coastal scientific areas and long-term experience with environmental assessment and monitoring, including the coordination of several ongoing state monitoring programs. JEL also has unique analytical expertise for microbial contaminants and biological monitoring. The UNH Water Quality Analysis Laboratory (WQAL) has the capacity for a wide range of water quality analyses as well as associated field experience in freshwater ecosystems. The UNH Stormwater Center is another group conducting ongoing assessments of the impacts and management of stormwater in the Seacoast. At present, these and other UNH groups can work together or be engaged as separate entities for specific analytical and scientific oversight needs by towns to help address stormwater issues. The NH Department of Environmental Services, other relevant state agencies (NH Fish & Game Dept.) and environmental organizations (Piscataqua Region Estuaries Partnership-PREP, Great Bay National Estuarine Research Reserve-GBNERR-Table 1) also offer analytical and/or scientific advisory expertise. It is also important to work with all of these groups to make sure efforts are not duplicated and limited resources can be leveraged.

Additional monitoring program participation and coordination needs include a clearly defined organization of responsible town authorities, a single program coordinator, volunteer leaders, volunteer participants and interested partners. Clear means of communication and contact informaiton will be needed, optimally directed in all directions through the monitoring program coordinator.

Study site and storm drain selection

There are typically many storm drains that are known to exist in urbanized areas of towns, yet certain drains are, for a variety of reasons, considered to be more important than others. The evidence for this prioritization includes reasons why they would be most likely to be problematic, like flow volume and proximity to potential pollution sources. Because of extensive efforts by NHDES to find and sample storm drains in the NH Seacoast, there is often existing water quality data that can be used to compare and prioritize drains for monitoring. Specific storm drains that are part of existing management projects can also be targeted. Without relevant existing information to help prioritize monitoring sites, sites may also be selected based on the need for spatial representation to cover an impacted watershed, different types of drains and drains within different types of land uses. The site selection process should also include a review of related (e.g., surface water, biological monitoring) programs. There is a benefit to all entities when different groups seek to harmonize procedures, share resources and coordinate sampling in time and space.

The monitoring program participants will need maps and directions to selected storm drain locations. Pictures and site descriptions are also useful tools especially early on when sites are not yet familiar. It is important to document the condition of the storm drain and surrounding area so that relevant changes can be noted during the monitoring period.

Sampling design

Scientific questions and management goals that need to be addressed should be defined up front to ensure the sampling design and results will adequately address these questions and goals. The sampling goal for this plan is to collect and measure conditions and contaminants in water discharged from storm drains; sampling sites are thus defined as being storm drainpipe outfalls. Other related sampling approaches not covered here include monitoring for BMP performance, monitoring at long-term fixed stations, probabilistic and geographically comprehensive sampling of surface water or other ecosystem matrices, and flow-weighted sampling instead of grab sampling. All of these may be important parts of overall stormwater management plans for municipalities. In addition, many stormwater pollutants do not remain in the water column and instead often end up in sediments. Their impacts may also include long term ecosystem effects that are best captured through biological assessment approaches, in contrast to the ‘snapshot’ nature of grab sample analysis for water quality monitoring. Thus, it is important to collaborate and share data with sediment and biological monitoring programs, where and when possible, to provide comprehensive, ‘best-available’ information on stormwater impacts.

The number of sampling sites will be defined by how many volunteers are available, the number of pipes and their accessibility, and management related milestones for monitoring. For the recently completed pilot project in Greenland and Exeter, seven sites were monitored in Greenland on each sample date, and twelve Exeter sites were monitored, six on each sampling date. The range of 6-7 sites monitored at each sampling event took 2-3 hours, a favorable amount of time for volunteers to be in the field and for holding times for sample storage and analysis.

A variety of sampling designs relative to the number of monitoring sites are possible. For the pilot project, all volunteers worked together at all sites. In some monitoring programs, small groups or individuals are responsible for monitoring one or a few sites. The problem with the latter approach is that equipment is needed to do all of the measurements required to assess water quality, and that equipment is costly enough to make the multiple-team approach impractical in most cases. The original design considerations for the pilot project included splitting volunteers into two teams for Exeter so that all sites could be monitored at each sampling event. Because of the benefits of on-site training, a decision was made to have the Project PI present at each sampling event, precluding the situation where there would be two teams out at the same time in different areas of Exeter.

The number of volunteers involved is an important factor. Having all volunteers present at each sampling event in the pilot project allowed people to either specialize or to learn to do different tasks with supervision. Most of the time there were enough people present so that people could work together on tasks and help think through procedures, trouble shoot and socialize. On a few sampling events fewer people were present and people were able to conduct tasks on their own, once they were trained. We never had more than ten people present at any sampling event, though we could have accommodated a few more and they would have been engaged in monitoring tasks. Too many people would bring up other considerations, including how many people can be present at the site and parking/how many cars are needed. We were fortunate to sample at sites where parking and working space were not problems. As well, there were no sampling events where all participants were present, so it was obviously a benefit to have more volunteers than necessary to accommodate varying availability of volunteers during the study period.

A clear and consistent schedule for sampling frequency at defined locations is important when working with volunteers. They contribute their time and are often busy with other volunteer activities, so the predictability of sampling is important. Given this consideration, the pilot project was set up with a schedule for sampling that was defined over a 2-3 month period. The sample events were scheduled at the same day and time every two weeks, and this 'random design' schedule precluded weather as a pre-determining factor. It turned out half of the sampling occurred under 'wet' conditions ($\geq$ 0.5" rainfall/previous 48 h) and half during dry (< 0.5" rainfall/previous 48 h) conditions. Another timing consideration is the time of year for sampling. Often this is defined by pre-existing information that suggests when problems are most likely. Other considerations are dry weather flow, accessibility to pipe outfalls and the seasonality of potential pollution sources. Ideally, monitoring would take place throughout the year to assure towns that discharge water quality is assessed under a range of conditions.

None of the wet sampling events occurred during the 'first flush' of runoff from a rainfall event, as the pre-determined sampling schedule was not conducive to doing that. The ability to respond to runoff and/or extraordinary weather events is an essential part of stormwater monitoring. It is something that could be done with volunteers, though typically with a smaller group than would be involved in regularly scheduled sampling, and with a heightened degree of safety precautions. The pilot project did require flexibility in sampling responses to get samples around tides, and a number of volunteers were able to get involved.

Once the number of volunteers, sampling sites and the timing of sampling events are set, the decision of where sampling will occur can be made. In Exeter where there were too many sites to sample on any single date, the sites were grouped by geographical location-to the east and to the west of downtown. This approach minimized transportation costs, and it allowed for both comparison of results and combining data to estimate pollutant loading from sites within a defined area. In both towns the order of sampling was also important, and best conducted in a predictable way and to minimize transportation costs.

Organization & oversight of volunteers

Volunteers are motivated to become involved in water quality monitoring for a variety of reasons. Many people are motivated because protection of water quality is something they believe in, while others may be motivated to learn new skills or to meet new people. Volunteer groups often include people with a wide range of backgrounds, interests and ages. Their continued participation depends to a large extent on how well the monitoring program is run, as well because they see the findings are useful and they are given respect and recognition.

Volunteers can be recruited in many different ways when starting a storm drain monitoring program. Some volunteer programs already exist, like the CRV Program and watershed associations (Table 1). To help recruit local volunteers in areas without a watershed association, town and other communication systems, like volunteer hotlines, web pages, notices in town hall and libraries, press releases, town newsletters and project brochures can be used to attract citizens to action. Many existing volunteer programs require new volunteers to fill out applications and liability statements, and these programs provide an invaluable means of communicating with a large number of members about new volunteer opportunities.

Key factors in assembling a group of volunteers include knowing how many are needed, when during the day will they be involved, what physical and educational background is needed and what degree of reliability and flexibility is needed. Typically there are minimum, maximum and optimum numbers of volunteers needed, depending on the sampling design (see below). Practically speaking, volunteer groups often start out with too many people and end up with either optimal numbers or too few people. This is something that should be planned for in terms of contingency plans for too few and too many people on any given sampling event. To fully capture the interest of too many volunteers, a system of assigning participation on different sampling dates is an alternative approach.

The monitoring program needs to be carefully and thoroughly planned to enable clear explanation of it to volunteers and to ensure its smooth operation. Effective training is required, and frequent and timely communication is critical for retaining volunteers' interest and engagement. The communication structure of the program should be explained and everyone should know who to contact and how. Reminders about each sampling event, even if they are planned out months in advance, are also useful for keeping communication open and flowing. Updating volunteers on findings is another useful means of continuing to give the volunteers a sense of the functioning of the group they are working with. The monitoring program coordinator, staff and town partners can maintain the quality of the program and retain volunteers by meeting their expectations and motivations, providing fun and informative social dimensions, and demonstrating to them the application of program findings. It's also important to give encouragement and recognize effort, provide continuing educational opportunities, and to get volunteers involved in presentations and outreach activities.

Parameters, measurements and detection methods

Storm drains can be sources of many pollutants, and an array of parameters can be chosen to reflect local problems and regulatory requirements. Many parameters are contaminants of concern or indicators of pollution sources, or they can be included to help interpret other measured parameters. The parameters chosen can reflect available field measurement instrumentation and lab analyses, or they may require the purchase of new instruments and paying labs for analyses.

There are many options for detection and measurement methods, varying in complexity, cost and required instrumentation. Many acceptable methods for laboratory analysis of pollutants in water are included in the US Code of Federal Regulations list of acceptable detection methods for the USEPA (eCFR 2012). Many parameters have acceptable field kit detection methods that can be purchased with minimal instrumentation needs and that can used directly in the field. As previously mentioned, several university and state labs in the area have long-term and extensive experience in measuring water quality parameters as part of other research studies and monitoring programs. One consideration in choosing which methods and what laboratory to be used is the potential to compare findings with other studies. Thus, local and state labs already involved in ongoing studies and monitoring can serve that purpose as well as be able to better respond to problems, questions and concerns about analyses for local studies. Other accredited labs are listed by NHDES (Table 1).

Each parameter selected will require specific sampling and storage conditions. Depending on the analysis method to be used, different types of sample containers will be needed to ensure quality analytical data can be obtained for all parameters. Some parameters will require storage under refrigeration, others require freezing and some can be stored at room temperature. Some require preservatives added to the storage container and all have specific holding times, beyond which data are unacceptable. Table 2 shows the requirements for all parameters measured or analyzed in labs that were used in the pilot project in Greenland and Exeter.

Parameter	Indicator	Lab/method	Container*	Preservation	Maximum holding time
E. coli	Sanitary wastewater	UNH-JEL	PA, G	<10°C, 0.008% Na_2S2O_3	6 hours
Total N	Sewage, animal waste, fertilizer	UNH-WQAL	P, FP, G	Freezing @ -20°C	28 days
Ammonia	Sanitary wastewater	UNH-WQAL	P, FP, G	Freezing @ -20°C	28 days
Chlorine, total residual	Potable water	Field kit	P, G	None required	15 minutes
Chloride	Road salt, sewage, estuarine water	NHDES lab	P, G	Refrigeration: 4°C	28 days
pH	Natural & polluted water	Meter	P, FP, G	Refrigeration: 4°C	14 days
Turbidity	Natural & runoff material	Meter	P, FP, G	Refrigeration: 4°C	48 hours
Dissolved oxygen	Oxygen demand	Meter	P, FP, G	None required	Immediate
Specific conductance	road salt, polluted water	Meter	P, FP, G	Refrigeration: 4°C	28 days
Salinity	Road salt, estuarine water	Meter	P, FP, G	Refrigeration: 4°C	28 days
Temperature	Many factors	Meter	P, FP, G	None required	Immediate

*P=polyethylene; G=glass; LDPE=low density polyethylene; FP=fluoropolymer (polytetrafluoroethylene (PTFE; Teflon®); PA=polypropylene or other autoclavable plastic

Table 2. Water quality parameters, sample bottle containers, preservation and maximum holding times for measurements and analyses conducted in this project.

Additional parameters that have been included in other storm drain and water quality monitoring programs include alkalinity, hardness, potassium, total phosphorus, total suspended solids, trace metals (Cu, Pb, Cr, Cd, Zn, Hg), chlorophyll *a*, BOD, oil and grease and surfactants.

IMPLEMENTATION

Training

Volunteers engaged in storm drain monitoring need to be well trained to ensure their safety and that useable, high-quality data can be obtained. Initial and on-going training are time consuming and demanding, yet are essential aspects of a successful monitoring program. All training sessions require a climate that is collaborative, respectful, mutual, and informal to ensure that adult volunteers learn the correct methods for collecting and analyzing samples.

An effective training session is best held at a location where volunteers can experience field and laboratory conditions in addition to presentations in a comfortable setting. It is important that enough trainers are present to make sure all volunteers are engaged in the training. The training session agenda should include a presentation of project goals and objectives, what participants will be expected to do as part of the training session and the project, time commitments, an explanation of all equipment and supplies that will be used, record keeping, site descriptions and data recording, and an overview of safety requirements and monitoring procedures. In the field setting, volunteers can witness demonstrations of field sampling procedures and use of water quality measurement equipment. Following demonstrations, volunteers can practice use of equipment and sampling procedures while supervised by the trainers. A laboratory setting is useful for demonstrating proper storage of samples and processing procedures sometimes required prior to sample storage. Proper procedures can be demonstrated and volunteers can practice with lab water. A final meeting of the whole group is a great way to end the training session to discuss questions, re-emphasize safety considerations and discuss next steps. Feedback on how well the training session went is valuable information for the program and should be included by having volunteers evaluate the session. The trainers should avoid presenting too much information at once, and should keep the volunteers engaged in a friendly and fun atmosphere.

Training never stops in monitoring programs where the coordinator and trainers are present with the volunteers during sampling events. In fact, the next step after the initial training session can be to conduct a site inspection event that includes on-site training with equipment and sampling procedures. This provides an opportunity for the trainers to address site-specific safety issues and conditions that may affect how sampling and measurements are conducted, encourage questions and insights from the volunteers, and begin reinforcement of proper procedures. Volunteers can also be informed of any site-specific contingencies about sites, like tidal influences and permission from owners and abutters.

Data quality objectives

One of the key questions to ask at the start of a monitoring program is what are the data quality objectives? If data are to be used as guides for where to conduct follow-up studies, then the procedures and analyses may not have to be that robust. If the desire is to use the data for more exacting purposes, then procedures and the data produced will have to pass certain criteria. One mechanism for doing this is to write a Quality Assurance Project Plan (QAPP). Depending on the experience of the town or program partners with previous projects, there may be an applicable QAPP or two that can help form the basis for the overall project QAPP. At the least a new QAPP would be needed to provide project-specific information. A QAPP is reviewed by the agency that will be using the data, like the NHDES or US EPA Region 1. An approved QAPP can then be used as a guide for all procedures used in the project, and can help to assure that the data quality objectives are met.

Pre-sampling activities

Prior to initiating sample collection and water quality monitoring, a meeting can be held in the town to describe the project goals and objectives, review field procedures and organize the volunteers that have committed as program participants. The volunteers can then travel to the proposed study sites to inspect the pipe outfalls to see if there is flowing discharge and whether the site is accessible and safe for sampling. Safety hazards should be noted, including poison ivy, slippery conditions, traffic, mosquitoes/ticks, and any other condition that would justify extra care. Sites are then accepted or rejected, and a final sampling plan can then be formulated.

As previously mentioned, this initial site inspection step can also be used for on-site training. The trainers can establish field procedures for sampling, demonstrate how to record the site and weather conditions, practice with in-field measurements and point out critical control points where safety precautions are most essential.

Protocols for field sampling and measurement

A Checklist is a valuable mechanism for making sure nothing that is required in the field is left behind. The Checklist should include materials and equipment needed for the sampling and water quality measurements, safety and first aid supplies, data sheets and clip boards, labeling tape and markers, tool box, extra batteries, de-ionized water, tape measure, towels, Kimwipes and whatever else is needed.

The first thing to discuss upon arrival at sampling sites is safety precautions that are required and other concerns that may be specific to the site. Sampling can only occur if water is coming out of the pipe, so that is confirmed next. Volunteers are needed for each task, and the coordinator can then supervise the timing of tasks to optimize time spent on site and ensure that procedures are conducted in the correct order. The initial sampling events are typically great opportunities to let volunteers make some mistakes to see what procedures need improved written instructions and also to demonstrate the implications of incorrect procedures.

The first actual monitoring tasks include sample bottle labeling and calibration of instruments by some volunteers while others can start collecting samples or recording site conditions. The data recorder needs to be present when people read off numbers for calibration and actual data collection from water quality measurements. The sampling should take place in order to minimize waiting for incubation steps that may be parts of field detection procedures. Sample bottles for laboratory analysis almost always require immediate storage in a cooler, while other samples needed for in-field measurements should not sit around because these parameters often require immediate measurements. After the sampling volunteers have stored all analysis sample bottles, given the other volunteers samples for in-field measurements, and cleaned all sampling equipment, they can go back and determine flow rate, when possible. Field duplicate samples should be collected for lab analysis at a frequency of 10% of the samples.

Meanwhile, other volunteers should be finished with calibrating the field instruments and underway with taking measurements in the collected water samples. Succinct and clearly written instructions can be printed out and laminated for use in the field. Volunteers can simply follow instructions while the data recorder does their job. A duplicate sample from one site should be included in each sample event-day for field measurements. Once measurements are taken and data recorded, all instruments should be cleaned, rinsed and stored according to instructions either for the end of the day or for the next site. Halfway through the sampling date, instruments should be re-checked against standards to determine any drift in readings, and re-calibrated if necessary. This step should also be conducted at the end of the day. Any problems with instruments or sampling should be clearly documented on the site data sheets, and any pollution sources (animals, trash, etc.), unusual circumstances or site condition changes should also be noted. Prior to leaving the site, another Checklist should be used to check that all samples, measurements, QA/QC steps, and cleaning procedures have been taken care of.

Post-sampling

At the completion of the sampling event, samples for lab analysis need to be promptly transported to the storage area and stored as required prior to analysis. Bacterial analyses have a six-hour holding time, so those require analysis soon after sampling. All sample transfers should include documentation in the form of chain of custody forms or sample inventories, with dates, times and names of people involved in the transfers. Some samples like dissolved nutrients require pre-storage processing (filtration) according to clearly written instructions using all required materials.

Lab analysis

As previously described, some parameters require analysis by professional or outside laboratories. These labs should be informed well ahead of time to anticipate the delivery and the time requirements for analysis of the program's samples. Samples can only be stored within designated holding times before being deemed unacceptable for analysis. The analytical lab should provide documentation of their QA procedures and results for the program's analyses. Reporting of results to the program coordinator should be in a timely fashion, and receipt of results should be in the pre-determined format required by the program.

Record keeping

The data sheets used in the field should be transcribed into electronic files on a computer, and two people should be involved in verifying accurate transcription. Records of who, what, when, where for sampling events, and analysis results should all be transcribed into multiple copies of computer files. All collaborations with other groups, or changes made like additional sampling and pipes, or the cessation of sampling at other pipes, should be documented as they occur.

Costs

The cost for conducting a storm drain monitoring program depends on many factors. There are some common cost categories that all monitoring programs share, including program coordination and associated costs, sample analysis, transportation, supplies and maintenance and calibration of instruments (Table 3). There are also some benefits realized through the participation of volunteers, including their time and transportation costs, as well as any waived costs or donated use of instrumentation, sample analyses and scientific advice!

Cost category	Explanation
Program coordination	Part-time support for the program coordinator: time and costs
Insitutional costs	Coordinator benefits, employer overhead
Sample analysis	Professional lab coss per sample, savings for higher number of samples
Transportation	Transportation for sampling, presentations, meetings
Supplies	sampling supplies, detection kits, presentation materials
Maintenance	Field instrument maintenance, calibration, standards
In-kind support	
Time	Volunteer time spent on monitoring, training, meetings
Transportation	Volunteer transportation for all activities
Instrumentation	In-kind use of existing instrumentation, waived analysis costs
Scientific advice	Time spent by outside experts giving advice

Table 3. Costs and benefits for volunteer monitoring programs.

APPLICATIONS

The main application of monitoring plan findings is to identify pollution sources. Verification of which storm drains are significant pollution sources is crucial information for directing resources to support follow-up mitigation and management actions. The most effective way to coordinate this activity is to maintain communication between the monitoring program coordinator and town contacts who can respond to findings as they happen. An immediate response to the finding of a storm drain discharging high levels of fecal-borne bacteria/sewage would obviously help to diminish potential public health risks. A review of findings over a longer time period, or at the end of a study period can also reveal conditions that help to assess the severity or lack of pollution sources and help to focus resource allocation and management responses. Monitoring results can also inform the development and implementation of TMDLs. Finally, ongoing monitoring during and after any management actions can help to assess the effectiveness of BMPs and other stormwater pollution reduction measures.

The educational value of volunteer participation is multi-fold. Volunteers that participate in the monitoring program will gain knowledge of scientific methods, field assessment methods, lab detection techniques and data interpretation skills. As citizens of the area, they will also help to inform their neighbors and fellow community members about their experiences and the program findings, thus cultivating an enhanced sense of stewardship for the ecosystem within the community. The findings are also valuable educational tools in that they provide a knowledge basis for considering human impacts on water quality and ecosystem health, and thus inform environmental and public health agencies as they seek to manage pollution issues.

Data generated from the monitoring can be invaluable additional information for managers to consider for allocating resources to address water quality impairments. Monitoring results can help to document pollutant loadings and trends for watersheds, and provide a more informed perspective on the significance of stormwater pollution on local and regional scales. Communication of results in public forums and scientific meetings can be invaluable mechanism for two-way learning; sharing findings with other groups and learning from their experiences, data and insights in return.

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