# CHAPTER 10: ELEMENT I. - MONITORING

The Deer Creek Watershed Management Plan reflects management measures that when implemented are intended to improve the water quality within the watershed. Monitoring programs will be designed to track the progress in meeting load reduction goals and attaining water quality standards. It is important to specify monitoring objectives that, if achieved, will provide the data necessary to satisfy relevant management objectives. The selection of monitoring designs, sites, parameters, and sampling frequencies will be driven by agreed-upon objectives and will include factors such as site accessibility, sample preservation concerns, staffing, logistics, and costs.

Measurable progress is critical to ensuring continued support of watershed projects, and progress is best demonstrated with the use of monitoring data that accurately reflect water quality conditions relevant to the identified problems. Frequently watershed managers rely on modeling projections or other indirect measures of success (e.g., implementation of management measures) to document achievement; in some cases this approach can result in a backlash later when monitoring data shows that actual progress does not match the projections based on surrogate information.

Because of natural variability, one of the challenges in water quality monitoring is to be able to demonstrate a link between the implementation of management measures and water quality improvements. Monitoring results will be used to track long term changes in Deer Creek.

## MONITORING INDICATORS FOR INITIAL DEER CREEK WATERSHED PROJECTS

Two monitoring programs are proposed for initial projects in the Deer Creek Watershed. The first seeks to assess the effectiveness of pollutant removal by three Best Management Practices. Other than anecdotal evidence there is no preexisting monitoring data for the three sites embodied by this project, which demonstrates the importance of the scheduled monitoring activities. Sites are being investigated in the current study include ones where low lying properties have experienced recurrent flooding and/or erosion.

The second program seeks to quantify the effectiveness of 5 to 10 Rain Gardens without underdrains and to monitor effectiveness with plant growth. The data may be used to expand use of Rain Gardens without underdrains, greatly reducing the cost of rain gardens and increasing their applicabilty.

## FIRST PROGRAM – BIORETENTION PROJECTS

The goals of the water quality monitoring are to confirm, identify, and qualify the timing and magnitude of water levels, suspended sediment, an organic related pollutant, and rainfall at up to three demonstration bioretention projects and compare the initial results with post-best management practices (BMP) results using statistical comparisons and the STEPL model to quantify reductions or variations in system behavior.

Monitoring results will guide Metropolitan St. Louis Sewer District and municipalities regarding the degree to which bioretention methods should be impelemented in the watershed. Monitoring will be conducted for following:

**I. Flow**
Water Level - Continuous monitoring equipment will be employed to monitor water levels associated with these features during rainfall events. Discharge calculations can be made from these measurements.

**II. Nutrients**
Phosphorus - phorphorus is an organic related contaminant. Monitoring this parameter will address problems that might arise from organic contamination including health risks, low dissolved oxygen, large debris accumulations, and negative vegetative community impacts.

**III. Chloride**
Chloride measurments will help document degredation of water quality due to application of rock salt on pervious pavements relative to impervious parking lots and will help document the effectiveness of forebay and underdrain additions to bioretention systems to protect groundwater supplies from chloride contamination in high karst areas.

**IV. Bacteria**
Sites will be monitored for E. coli and total coliform levels.

Activities associated with the monitoring will include:

**I.Reviewing Past Data** - Data products for the G09-NPS-13: Missouri Botanical Garden Deer Creek Watershed Initiative: Addressing Effectiveness of Implemented Green Infrastructure Demonstration Projects on Water Quality in the Deer Creek Watershed project will be used to determine water quality information prior to the demonstration projects' installation as well as chart the behavior of water quality after the installations are completed.

**II. Journal Articles -** Relevant journal articles that deal with the effectiveness of similar projects (Chloride Found at Levels that Can Harm Aquatic Life in Urban Streams of the Northern U.S.--Winter Deicing a Major Source, USGS report; Saturation to Improve Pollutant Retention in a Rain Garden, Dietz, M. E., Storm-Water Infiltration and Focused Recharge Modeling with Finite-Volume Two-Dimensional Richards Equation: Application to an Experimental Rain Garden, Aravena, J, E. and Dussaillant, A.

**III. Field Monitoring -** Extensive field monitoring will be performed at the following sites:

A. 10920 Chalet Court – The Chalet Court neighborhood is an urban neighborhood in the Deer Creek watershed where yard erosion is occurring at a pipe outlet. A Deer Creek tributary that flows behind the home is undergoing significant erosion and entrenchment.

B. Mount Calvary Church and Adjacent Neighborhood – The Calvary Church and its adjacent urban neighborhood is located in the Deer Creek watershed. The low-lying neighborhood homes that are in the storm water flow path have experienced repeated yard and structure flooding.

C. 8360 Cornell Avenue – Homes along Cornell Avenue are also located within an urban neighborhood in the Deer Creek watershed. The storm water flow path is behind the homes. The home at the low point of the neighborhood has experienced repeated yard flooding and other yards have experienced erosion.

IV. Given the ephemeral nature of the demonstration project sites, the monitoring schedule will be inherinently linked to rainfall events.

Monitoring will occur at inlets above the BMP demonstration projects as well as below the systems to compare effectiveness of the BMPs. These data results will be compared to pre-BMP data obtained during the G09-NPS-13: Missouri Botanical Garden Deer Creek Watershed Initiative: Addressing Effectiveness of Implemented Green Infrastructure Demonstration Projects on Water Quality in the Deer Creek Watershed project.

Over a propsed four year period a sufficient number of storm samples will be collected to determine the effectiveness of BMP implimentation on water quality. Further, given this period there should be adequate time for re-sampling if necessary.

Flow, nutrient, and bacterial data for the sites will be compared to data products generated during the G09-NPS-13: Missouri Botanical Garden Deer Creek Watershed Initiative: Addressing Effectiveness of Implemented Green Infrastructure Demonstration Projects on Water Quality in the Deer Creek Watershed project which will monitor water quality prior to the demonstration project installations. In addition, water quality will also be monitored above the system and below to determine how the installation affects water quality.

**I. Field Work**
A. Danelle Haake (Litzsinger Road Ecology Center)
B. Elizabeth Hassenmueller (Washington University in St. Louis)

**II. Laboratory Work**
A. Danelle Haake (Litzsinger Road Ecology Center) - Sample processing
B. Dr. Robert Criss (Washington University in St. Louis) - Data analysis

**Analysis:** Data will be reviewed by the monitoring team to identify potential problems, maintain awareness of site conditions and field practices, double check analytical results, and to verify accurate entry into the database. Data will be assessed by comparing pre-BMP and post-BMP data, comparing data obtained from above and below the installation sites, statical comparison, determination if water quality parameters are above or below their MDLs, compare data to models, and data averages per season, year, and month.

**Reporting:** The monitoring team will submit quarterly reports to the primary sponsor, project manager, and to MoDNR. These reports will include details of activities completed during the previous quarter, a database of results, any pertinent data products such as graphs or figures, an assessment of the activities scheduled for the coming quarter, and a record of volunteer time contributed to the project.

**I. Field Measurements, Handheld Meters:**

A. Temperature
B. Specific Conductivity
C. Dissolved Oxygen
D. pH
E. Turbidity

**II. Rainfall:**

A. Rainfall gauge

**III. Field Measurements - Continuous Monitoring Equipment**

A. Temperature
B. Water Level

**IV. Field Sample Collection**

A. Autosampling device

**V. Laboratory Measurments - Chemical and Bacterial**

A. Chloride
B. Reactive Phosphorus
C. E. coli
D. Total coliform
E. Turbidity

Quality Control Efforts - Accurate, reliable field measurements and analytical results depend upon consistent methods, careful execution of procedures, quality supplies, and properly maintained instrumentation. All of these aspects can be tested and verified through a well designed quality control program as follows:

**A. Training -** All personnel employed by the WUSIL are required to complete laboratory safety training.

**B. Quality Control Measures -** Each activity conducted during this project has an associated QC measure to track accuracy, precision and bias, identify problems, and trigger remedial action.

i. **Duplicate Measurements and Analyses** - To test the precision of field and laboratory instrumentation, duplicate analyses or measurements will be conducted on samples at a frequency of 1 duplicate for every 10 "normal" samples. In the field, meters will be used to collect duplicate readings from the same location and these values should not vary by more than +/- 20% from the original value. Sample collection activities will include a duplicate for every 20 "normal" samples to verify that collection procedures do not influence analytical results, and to evaluate the precision of analytical methods and the temporal variability of each parameter. The duplicate sample should be collected within 5 minutes and at the same location as the original sample. Duplicates will be labeled according to standard practices but will include the word "Duplicate." Any result for a duplicate sample that varies by more than 20% of the original value will be considered unacceptable and trigger a corrective action.

ii. **Equipment and Laboratory Blanks** - Blanks are samples that consist of deionized (DI) water that is processed in exactly the same manner as a "normal" sample. This practice can identify errors

or bias that might be caused by contaminated reagents, collection bottles, malfunctioning equipment, or improper procedures. An equipment blank will be conducted on all field meters prior to each field excursion. Each instrument will be used to measure the appropriate parameter in a sample of DI water and results will be recorded.

iii. **Reference Samples and Matrix Spikes -** Accuracy and bias assessment will be conducted using reference samples and matrix spikes. Reference samples consist of the measurement or analysis of a sample with known composition. Field instrumentation and laboratory procedures will be tested against reference materials.

iv. **Calibration Procedures and Frequency -** Field meters will require periodic calibration to ensure that all data are accurate and comparable. Many of the devices execute self-testing whenever the units are turned on and report errors if warranted. All instruments will be checked regularly against standard solutions on the schedule. Any parameter with results outside of the accuracy range specified by the manufacturer will indicate that the meter should be recalibrated, serviced, or replaced.

Page ten of the document located at http://faculty.capd.ksu.edu/lskab/KSU-LARCP_Rain-Garden-Guidebook-lrs.pdf, outlines a three-step infiltration test that can be used to determine soil classification and infiltration rates.

## SECOND PROGRAM – MONITORING WATER QUALITY IN DEER CREEK AND IT'S TRIBUTARIES

The monitoring of water quality in Deer Creek and its tributaries will be pursued by both Metropolitan St. Louis Sewer District and Litzsinger Road Ecology Center. USGS/MSD monitoring is high quality data that can be used to document water quality trends at 4 stations within the Deer Creek Watershed, which can also be used to model water quality pollutant loads. Stream Team data can be used to document long-term trends documenting gross changes in water quality, and Stream Team aquatic macroinvertebrate data can be used to document gross changes in aquatic life.

The Litzsinger Road Ecology Center (LREC) Stream Team data is collected on a monthly basis at seven points in the upper Deer Creek watershed, including the tributaries of Twomile Creek and Sebago Creek. This type of sampling is ideal for getting a picture of typical conditions in various portions of Deer Creek and its tributaries. The LREC team is unlikely to be capturing either the highest or lowest values for the parameters that they measure.

It is important to note that LREC monitors do not collect samples during the high-flow periods associated with storm flow; LREC does not send staff or volunteers out during or immediately following major rainstorms due to concerns for their safety. Avoidance of these high-flow conditions results in not measuring water quality during some of the periods with the greatest loads of pollutants.

High concentrations of chloride have been found during the winter months (particularly early in 2008). These high concentrations exceed state water pollution limits at four of the seven LREC sites.

There have been several instances in which the saturation of dissolved oxygen was greater than 200% and up to 346%. This situation is often caused by the excess production of oxygen by algae or macrophytes. This is symptomatic of a system in which supersaturated daytime conditions are followed by sags in dissolved oxygen as overnight respiration causes oxygen concentrations to plummet once the sun goes down and photosynthesis ceases.

Generally, nitrate concentration and turbidity are both below the detection limit of LREC equipment. However, there are noticeable amounts of turbidity during periods of higher flow.

Additionally, Metropolitan St. Louis Sewer District (MSD) currently monitors 34 sites throughout its service area for the Stream Monitoring Program. The purpose of the Stream Monitoring Program is to gather information during storm and non-storm events, to assess the impacts of CSOs/SSOs and gather background data for these water bodies. The list of parameters and the monitoring frequency for this program is not static. Currently the goal for the monitoring program is to monitor all streams monthly.

The current list of parameters for the stream monitoring program is as follows: Chemical Oxygen Demand, pH, Temperature, Ammonia (as N), Chloride, Dissolved Oxygen, E- coli, Enterococcus, Fecal Streptococci, Hardness, Cadmium dissolved, Chromium dissolved, Copper dissolved, Iron dissolved, Lead dissolved, Nickel dissolved and Zinc dissolved. In order to determine impact from the various contributing streams, sampling locations were established at the mouth of the contributing stream. As part of the Stream Monitoring Program, Deer Creek is one of the streams being sampled.

With this information, progress toward the overall goal of the plan can be assessed/tracked overtime. Both direct water quality measurements and models can be used to track progress of the watershed management plan. See Appendix 10-A for a detailed overview of MSD protocols.

The data collected from the LREC Stream Team and MSD will be analyzed every three years to determine water quality changes in Deer Creek.

## QUALITY ASSURANCE PROJECT PLAN (QAPP) FOR MONITORING THE EFFECTIVENESS OF IMPLEMENTED GREEN INFRASTRUCTURE DEMONSTRATION PROJECTS ON WATER QUALITY

A quality assurance project plan (QAPP) has been developed by Washington University for the monitoring efforts to support the objectives of the green infrastructure demonstration projects in two ways:

1. Gather and review of available historical and current water quality and stream discharge data to identify potential pollutants effecting water quality. This information will be used in the development of the Deer Creek watershed management plan, and

2. Document the effectiveness of three small scale green infrastructure demonstration projects within the Deer Creek watershed.

The design goals for the three MSD demonstration BMPs are as follows:

1. Implement plant-based demonstration projects that reduce water pollution in the Deer Creek watershed employing a green infrastructure approach.

2. The performance goal of all green infrastructure techniques will be capturing, treating, and detaining stormwater runoff from 90% of the recorded daily rainfall events, which is based on a rainfall amount of 1.14 inches. Opportunities to design for larger events and incorporate enhanced infiltration techniques will be taken as downstream conditions warrant and with recognition that retrofitting in urban settings is a challenge.

3. Measure and document the effectiveness of the demonstration projects.

4. Monitor reduction in peak flow rates in relation to rainfall, overall volume reduction due to plant evapo-transpiration and infiltration, and effectiveness of the system in filtering at least one organic pollutant.

5. Leverage the demonstration projects as a marketing tool to increase social acceptance of stormwater bioretention methods in the Deer Creek watershed.

The QAPP for the demonstration projects is reflected in the Appendix to this Plan.

## EVALUATING & ADAPTING THE PLAN

This Deer Creek Watershed Management Plan reflects the conditions in the watershed as of 2010. This plan is intended to be working document and updated on a periodic basis to reflect projects that have been implemented, assign priorities to new projects, and reflect changes that occur within the watershed. Ideally every five years an addendum to this Plan should be prepared to reflect the current status of the watershed.

This watershed plan reflects issues and concerns expressed by citizens, municipal organizations and technical participants. Therefore joint ownership of this plan should be considered by all three entities and their continued involvement to evaluate its effectiveness and modify the plan as needed.

The municipalities within the watershed and St. Louis County should consider adopting this plan through either an ordinance or resolution which will allow the enforcement of those items requiring enforcement.

## MONITORING OVERALL GOALS AND PROGRESS

Litzinger Road Ecology Center and Metropolitan St. Louis Sewer District currently plan to continue water quality monitoring in the Deer Creek Watershed. These entities have agreed to share data, and this data will be used to document the long term effects/trends/improvements of the management practices in the Deer Creek watershed.

In addition, the Environmental Finance Center at Boise State University has developed and maintains a program called Plan2Fund which facilitates the monitoring of goals and objectives. The goals and objectives for the Deer Creek Watershed Plan have been inputted to this program and are reflected in the Appendix to this plan.