Quality Assurance Project Plan

for the

Quittapahilla Watershed Water-Quality Monitoring Program

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Problem

The Quittapahilla Creek in Lebanon County, Pennsylvania, is in need of help. The stream and all its tributaries have been designated as impaired by the Pennsylvania Department of Environmental Protection. In 2000, a Total Maximum Daily Loads (TMDL) report (Pennsylvania Department of Environmental Protection, 2000), listed sediment and nutrients as the primary causes for impairment. The 2018 Pennsylvania Integrated Water Quality Monitoring and Assessment Report (Pennsylvania Department of Environmental Protection, 2018) lists the Quittapahilla Creek and its major tributaries as Category 4a, "Impaired, not needing a TMDL because a TMDL has been completed." Therefore, the Quittapahilla Creek and its tributaries rank as high priorities for reduction of sediment and nutrient loads. Table 1 summarizes the current management classifications assigned to these waters.

Table 1. -- Management classifications for the Quittapahilla Creek and its tributaries.

Designation	Status	Notes
DEP designated High Priority Watershed?	No	
Approved Section 319 Watershed Implementation Plan (WIP)?	Yes	Approved by EPA, March 2021
Total Maximum Daily Load developed?	Yes	EPA approved -- 2001
Listed as impaired on the Integrated Report?	Yes	All Quittapahilla Ck. and tributaries
Priority for Chesapeake Bay WIP?	Yes	Lebanon County is a Tier 2 Priority

In addition, the entire Quittapahilla Creek Watershed is protected for "Trout Stocking Fisheries" (TSF) and for Migratory Fishes (MF) in Chapter 93 of the Pennsylvania Code (2020). There are conflicting reports on the ability of the stream to support a year-around trout fishery.

Finally, the Quittapahilla Creek and its tributaries provide water to the Swatara Creek. The Swatara Creek flows to the Susquehanna River and then to the Chesapeake Bay. Water problems of the Quittapahilla Creek Watershed eventually become problems for the Chesapeake Bay.

Background

The Quittapahilla Watershed Association (QWA) and the Doc Fritchey Chapter of Trout Unlimited (DFTU) along with our partners, Lebanon Valley College (LVC) and The Lebanon Valley Conservancy (TLVC), have been working to improve water quality in the Quittapahilla Creek Watershed. Our efforts have been successful. Within the last half dozen years, we have garnered support from the Pennsylvania Department of Environmental Protection, the Pennsylvania Fish and Boat Commission, the Lebanon County Stormwater Consortium, and the Conservation Fund for our stream improvement projects. We have used these funds for stream restorations, riparian buffer plantings, streambank stabilizations, and streambank fencing. In order to compete successfully for future funds, we need to show that our efforts are having an impact. Therefore, we are implementing the Quittapahilla Watershed Water-Quality Monitoring Program to evaluate the status of nutrients and sediment throughout the Watershed. We have prepared a Watershed Implementation Plan (WIP) to guide our work (Clear Creeks Consulting, 2018). The WIP describes the Monitoring Program and emphasizes its need.

The QWA, DFTU, and our partners are committed to building a volunteer monitoring program that produces relevant, accurate, and quality-assured data. Our program will be designed, managed, and operated by volunteers, but we expect the Quittapahilla Watershed Water-Quality Monitoring Program to be a cut above most volunteer monitoring programs. To that end, we have prepared this Quality Assurance Project Plan (QAPP) to explain our objectives, our training, our data collection protocols, and our quality-assurance and quality-control activities. We have relied heavily on guidance from the U. S. Environmental Protection Agency to prepare this document (U.S. Environmental Protection Agency, 2019a, 2019b) and on the Quality Assurance Project Plan of the Pennsylvania Department of Environmental Protection, Bureau of Clean Water (Lookenbill, 2020).

Project Description

The Quittapahilla Watershed Association, the Doc Fritchey Chapter of Trout Unlimited and our partners, Lebanon Valley College and The Lebanon Valley Conservancy, with support from the Lebanon County Stormwater Consortium, are undertaking a Monitoring Program for the Quittapahilla Creek and its tributaries. The program includes three components, each coordinated with the other and coordinated with plans for restoration of the watershed. The components are:

1. Geomorphic and habitat monitoring
2. Biological monitoring
3. Water-quality monitoring

The geomorphic and habitat monitoring has been and is being conducted by summer student interns undertaking environmental studies as their college majors. The biological monitoring is being conducted by Dr. Rebecca Urban and her students in the Biology Department at Lebanon Valley College. The water-quality monitoring will be carried out by volunteers from the Quittapahilla Watershed Association and the Doc Fritchey Chapter of Trout Unlimited. This Quality Assurance Project Plan (QAPP) deals with the water-quality monitoring aspect only of the overall Monitoring Program.

Project Purpose

We have three purposes for the Quittapahilla Watershed Water-Quality Monitoring Program:

1. Increase Public Awareness – Volunteers will be conducting the monitoring work. This type of community engagement will increase awareness of water-quality problems and the solutions for those problems. Our Monitoring Program will provide summertime educational projects for college student interns. There may also be opportunities for secondary school demonstrations, field trips, or educational videos that come from our work. We expect to inform the public of our work by highlighting our activities in local media outlets.

2. Undertake Scientific Studies – We hope to initiate research projects to (1) measure maximum summer temperatures, (2) determine locations of cold-water and warm-water inputs in the

watershed, (3) evaluate summer temperature spikes, and (4) measure summertime dissolved-oxygen concentrations in the mainstem. Results from these studies can lead to measures to remediate the issues. We anticipate that these research projects will be carried out by our summer intern students.

3. Influence Policy Decisions – Our monitoring data and reports will provide evidence that our stream-improvement projects are having an impact. This will give funding agencies confidence that funds they provide for our efforts will be used wisely. Thus, we should be better able to compete for future funding awards. Further, if we can show that the water quality of the Quittapahilla Creek and its tributaries is improving, there may be an opportunity to petition the Pennsylvania Department of Environmental Protection to remove the these waters from the list of impaired streams (the 303(d) list). In addition, Lebanon County is a Tier II county in formulating a revised plan to address issues in the Chesapeake Bay. We anticipate that our data will contribute to the plan devised by Lebanon County.

Project Objectives

The overall objective for the water-quality Monitoring Project is to characterize the nutrient and sediment status of the Quittapahilla Creek Watershed. Within that broad objective, we hope to:

1. Determine nutrient and sediment concentrations, loads, and yields for the mainstem Quittapahilla Creek and for each of its four major tributaries.
2. Determine if summertime temperatures exceed the tolerance limit for trout, and if so, where.
3. Pinpoint locations of cold-water inputs to the Quittapahilla Creek.
4. Determine whether runoff from summer storms results in temperature spikes in the Quittapahilla Creek that are lethal to trout.
5. Determine the levels of summertime dissolved-oxygen minima and compare them to conditions suitable for trout survival.
6. Evaluate the effects of stream-improvement projects on the water quality of Quittapahilla Creek.

These are ambitious objectives for a volunteer effort. It is especially difficult to collect enough information to satisfy objective 6, determining the effects of stream improvement projects. This is so difficult because a single improvement project, or even a few improvement projects within a watershed, will undoubtedly make a difference. That is, streambank fencing or bank stabilization will certainly reduce the amount of sediment and nutrients in a stream. But water quality is very variable. Water quality is influenced greatly by precipitation. High flow periods carry additional nutrients and sediment. So, the variability of rainfall may completely overshadow the gains resulting from stream-improvement projects. For this reason, we are collecting streamflow data at each of our monitoring stations. Our data analyses will take into account the influence of streamflow.

Study Area

The Quittapahilla Creek Watershed encompasses a 77.3 mi^2 drainage area of the Ridge and Valley Physiographic Province in Lebanon County, Pennsylvania. Quittapahilla Creek is a tributary to Swatara Creek which drains to the Susquehanna River. The headwaters of the Quittie begin just southeast of Lebanon, Pennsylvania and the stream enters the Swatara Creek near North Annville, Pennsylvania. Along the way, it courses through the city of Lebanon, Cleona Borough, and Annville Township. Water from Cornwall Borough and eastern portions of the Borough of Palmyra drain to the Quittie. Part or all of nine other Townships also lie within the watershed (Table 2). About 34 percent of the land in the watershed is considered to be developed and about 11 percent is considered to have an impervious cover. Almost three-quarters of the watershed is underlain by carbonate rock as determined by the USGS StreamStats tool (Ries and others, 2017).

Table 2. – Municipalities lying partly or wholly within the Quittapahilla Creek Watershed.

Municipality	Population[1]
City of Lebanon	25,477
Cleona Borough	2,080
Cornwall Borough	4,112
Palmyra Borough	7,320
Annville Township	4,767
North Annville Township	2,381
North Cornwall Township	7,553
North Lebanon Township	11,429
North Londonderry Township	8,068
South Annville Township	2,850
South Lebanon Township	9,463
South Londonderry Township	6,991
West Cornwall Township	1,976
West Lebanon Township	781
Total	95,248

[1]Source: U.S. Census Bureau, 2010 Census

There are four major tributaries to the mainstem Quittie (Table 3), all arising from South Mountain in the southern part of Lebanon County and flowing north through the Great Valley to the Quittapahilla Creek. The headwaters of these streams are in forested areas and they have high gradients. But quickly, the streams enter the Great Valley where the gradients are low, the currents are slow, and the land use is predominately agriculture and residential housing subdivisions.

Table 3. – Major tributaries to the Quittapahilla Creek.

Tributary	Drainage area (mi^2)
Snitz Creek	12.4
Beck Creek	8.1
Bachman Run	7.7
Killinger Creek	15.0

Monitoring Plan

The Water-Quality Monitoring Program is focused on assessing nutrients and sediment in the streams of the Watershed. We anticipate establishing six monitoring sites in the Watershed, two on the mainstem Quittapahilla Creek and one on each of the four major tributary streams (Figure. 1 and Table 4). Each of the tributary monitoring stations is near the mouth of the tributary. These stations are located so that they capture water downstream from our planned stream-improvement projects.

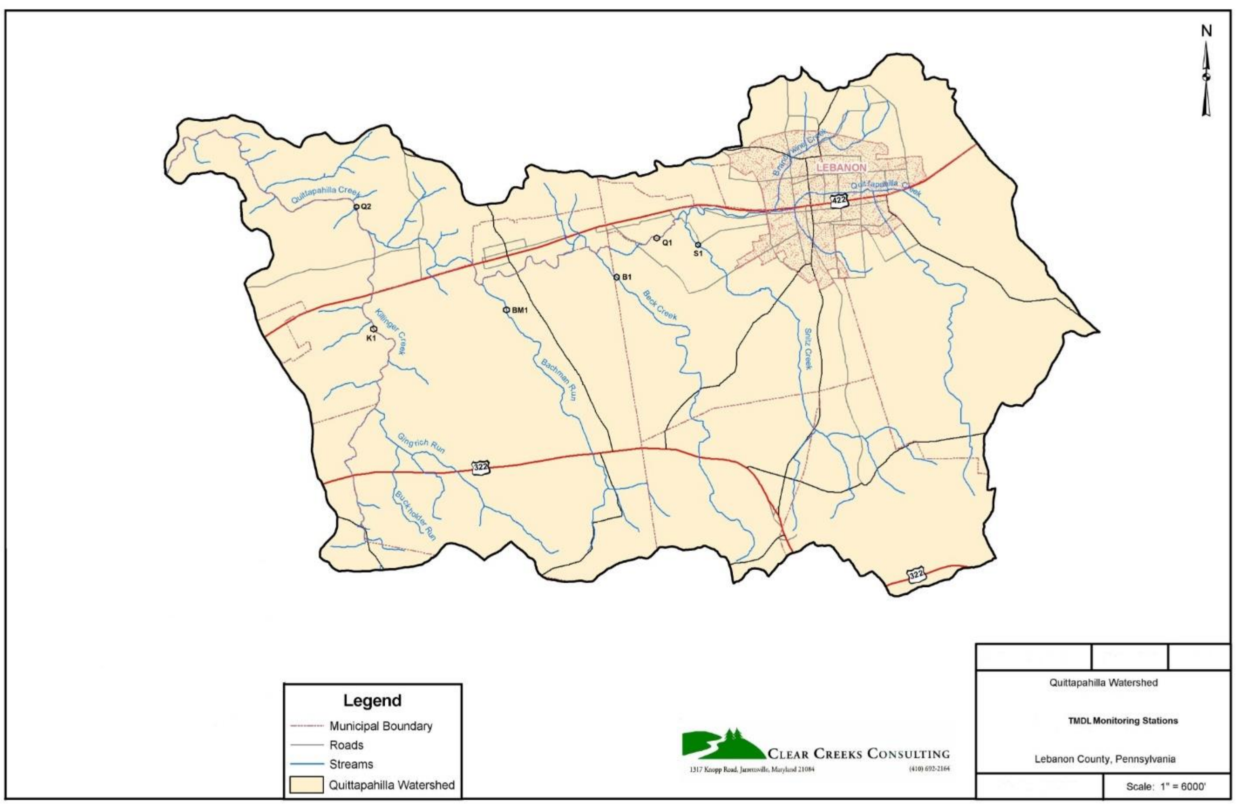

Figure 1. – Map of the Quittapahilla Creek Watershed showing locations of water-quality sampling sites (from Clear Creeks Consulting).

Table 4. -- Monitoring stations planned for the Quittapahilla Creek Watershed.

Station name	Station number	Drainage area (mi^2)
Mainstem stations		
Quittapahilla Creek at Garfield Street	Q1	32.7
Quittapahilla Creek at Palmyra-Bellegrove Road	Q2	73.4
Tributary stations		
Snitz Creek at Dairy Road	S1	12.4
Beck Creek at Bricker Lane	BK1	7.9
Bachman Run at Louser Road	BM1	7.3
Killinger Creek at Killinger Road	K1	10.8

Our sampling will target nutrients and sediment. These are the primary water-quality issues for the Quittapahilla Creek Watershed and are the reason for the “impaired” designation from the Pennsylvania Department of Environmental Protection. A wide range of nutrient fractions will be analyzed, including both dissolved and suspended forms (See Table 6c). We will measure total suspended solids which provides an approximate substitution for suspended sediment. In addition, we will measure major ions, (see Table 6d), and a limited suite of metals (see Table 6e).

Importantly, we will install continuous-recording stream gauges at each monitoring station. These installations will have a pressure transducer to measure the depth of water and a data logger to record these pressures. Also, there will be a staff plate at each monitoring station to measure depth of the water. The staff plate readings will be correlated to the pressure readings from the data loggers. We will take several manual streamflow measurements at each monitoring station and relate those measurements to the gage height of the staff plate by way of a rating curve (Figure 2). A rating curve establishes a relation between water level or stage (usually expressed as feet) and volume of water or discharge (usually expressed as cubic feet per second). This stage-discharge relation is called a rating curve. It is developed by making frequent direct discharge measurements at a stream gauge. By using the rating curve, the record from the pressure transducers can be translated to continuous stream discharge.

The chemical analyses for our samples will be performed by the Pennsylvania Department of Environmental Protection laboratory. More information is provided in the section of this document on Analytical Methods.

Extensive quality-assurance and quality-control measures will be employed. Details will be discussed in the sections on Quality Assurance and Quality Control.

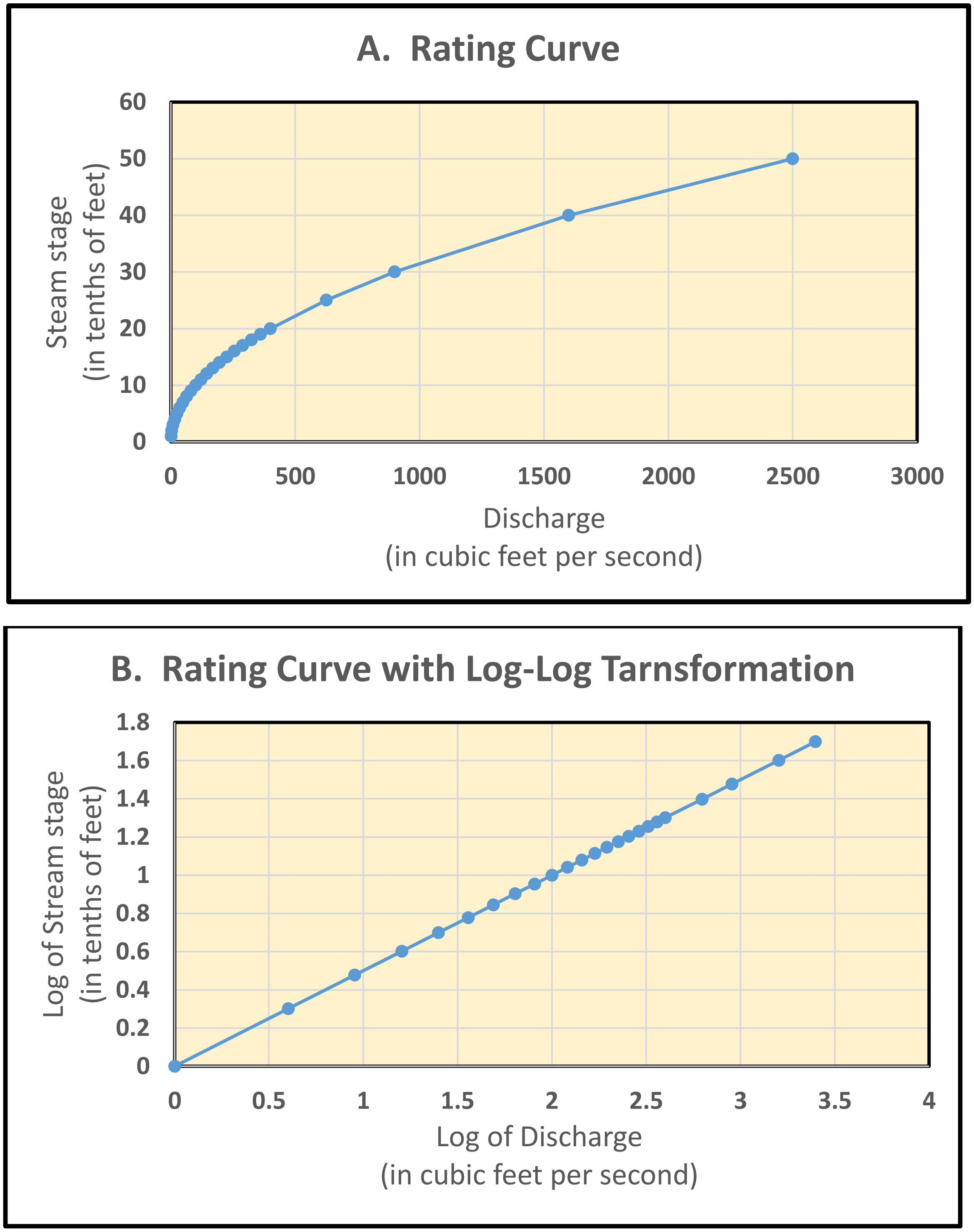

Figure 2. – Two examples of a stream discharge rating curve. The numbers to generate these graphs are made up. They are presented to show the concept of a rating curve.

<u>Project Schedule</u>

There are three components of our Water-Quality Monitoring Program:

- Bi-monthly sampling
- Storm sampling
- Special studies

Our goal for the bi-monthly sampling is to collect a water-quality sample six times per year at each monitoring station. Volunteers from DFTU and QWA will collect these samples. These samples need to be spaced out so that each season is covered. As such, there will be no set schedule, but samples need to be collected approximately once every two months. Our volunteers will collect these samples on a flexible schedule that fits within their other activities. There will be no requirement for a sample on the first of the month or similar constraint. However, we will emphasize the need to have samples representing all seasons of the year.

We know that most sediment and nutrients attached to sediment move during periods of high discharge or storm flow. So, we will make a concerted effort to collect samples during high-flow events. But, these hydrologic conditions are fleeting, especially in streams with small drainage areas like our four tributary streams. Therefore, it will be a challenge to collect these storm-flow samples. We will need to keep an eye on the weather forecast and be prepared whenever a storm is approaching. So, there will be no set schedule for the storm sampling, but we will collect our storm samples as the opportunities arise. Our goal is to collect six storm flow samples from each of two monitoring stations per year. This means that all six monitoring stations would be covered during a three-year period.

We have identified four research studies to be carried out in the heat of the summer when stream temperatures are highest and nighttime dissolved-oxygen concentrations in the stream are lowest. These studies will be carried out by summer intern students.

First, each of our pressure transducers will have a built-in temperature recorder that will provide a continuous record of stream temperature at five of the six monitoring stations. The sixth station (Quittapahilla Creek at Palmyra-Bellegrove Road) is a USGS streamflow station so we will not have our instrumentation installed there. The record of continuous temperature can be compared with temperature tolerance temperatures for trout to determine whether the Quittapahilla Creek and its tributaries can support trout in the hot summer weather.

Second, we envision a study of stream temperatures along the entire length of the Quittapahilla Creek mainstem. This longitudinal profile of stream temperatures will allow us to identify cold-water inputs such as springs or tributaries contributing cold water. From this work, we hope to protect cold-water inputs and remediate warm-water inputs.

A third study will examine temperatures in summertime runoff from impervious surfaces such as parking lots or urban areas. Summer storms may be providing hot-water inputs that result in stream temperature spikes too high for trout survival.

Fourth, we want to examine nighttime dissolved-oxygen concentrations in the Quittapahilla Creek and its tributaries. Warm stream water in the summertime holds less dissolved oxygen than cold water. In addition, at night, photosynthesis shuts down but respiration continues. These in-stream processes contribute to reduced oxygen levels. We will deploy continuous-recording water-quality instruments (water-quality sondes) to track these conditions. If low dissolved-oxygen concentrations are found, we may be able to devise programs to remediate the problem.

Our overall generalized project schedule is depicted in Table 5.

Table 5. – Generalized schedule for monitoring activities in the Quittapahilla Creek Watershed.

Monitoring activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bi-monthly sampling		X		X		X		X		X		X
Storm sampling			X						X			
Special studies							X	X				

Data Users

Our data will be used by the QWA and DFTU to demonstrate that our projects are having a positive impact on the water-quality of the Quittapahilla Creek. These data will support future applications for assistance from funding agencies.

In addition, the data generated from our monitoring activities will be used to guide future improvement projects. We are planning special studies of temperature and dissolved oxygen which will allow us to identify locations where cold-water inputs enter the stream and locations where dissolved-oxygen deficits occur. Knowing this information will allow us to implement projects to remediate the issues.

Pennsylvania is mandated by the U.S. Environmental Protection Agency to make major reductions in nutrients and sediment going to the Chesapeake Bay. The Commonwealth is far behind in making the required reductions. Because the Quittapahilla Watershed Water-Quality Monitoring Program will have discharge information associated with each water-quality sample, contaminant loads can be calculated. The Pennsylvania Department of Environmental Protection will use our data to support their load information submitted to EPA's Chesapeake Bay Program.

The Pennsylvania Department of Environmental Protection has developed their Phase 3 Watershed Implementation Plan (WIP) to guide the Commonwealth's path forward toward reaching the Chesapeake Bay Goals. County-wide planning is a foundation of the Plan. Lebanon County is a Tier II county and must develop a strategy to achieve local water-quality improvements. The Lebanon County Planning Commission is tasked with developing an "Action Plan for Clean Water" to guide the County's water-quality activities. Our data should be integral in that planning process.

Finally, PaDEP's Bureau of Clean Water will use the data generated from this Monitoring Program as part of their statewide assessment process. These assessments determine whether or not a stream is attaining water-quality standards. Streams that are not attaining their designated uses are added to the list of impaired waters. In the case of the Quittapahilla Creek, if remediation efforts are successful, our data can provide the information needed to remove the Quittie from the 303(d) list of impaired waters.

Data Quality

Data Quality Objectives

Data Quality objectives are statements (either qualitative or quantitative) that describe the acceptability of the data. For the Quittapahilla Watershed Water-Quality Monitoring Program, we hope to:

- Accurately determine nutrient and sediment concentrations and loads for the mainstem Quittapahilla Creek and its four major tributaries.
- Successfully operate streamflow monitoring stations throughout the year for a period of several years.
- Measure summertime stream temperatures at the hottest time of the summer.
- Measure stream temperature changes in response to summertime runoff from impervious surfaces.
- Determine whether some stream locations experience low dissolved-oxygen concentrations during summer low-flow periods.
- Determine water-quality changes resulting from stream-improvement projects.

Our data for ammonia nitrogen, nitrate nitrogen, dissolved oxygen, and pH will be compared quantitatively to the water–quality standards for these constituents. For sediment and phosphorus, numeric water-quality standards have not been established in Pennsylvania. Therefore, our comparisons will be qualitative and will be judged against criteria suggested by the U.S. Environmental Protection Agency.

In order to satisfy these objectives, our data will need to meet certain quality criteria. If water-quality trends are occurring, they will be small. Our measurements must be accurate and precise to be able to detect these trends.

Our work will need to cover the expected range of concentrations for each targeted constituent. The Quittapahilla Watershed lies mostly in an area of carbonate geology. Carbonate rock is highly soluble. Therefore, the expected values for specific conductance are quite high. We may see values for specific conductance as high as 800 µS/cm. Our calibration standards will need to span these high specific conductance values that we expect.

Similarly, we expect to find high concentrations of nitrogen in the streams of the watershed. The agricultural land use that is common in the watershed will contribute to high nutrient concentrations in the water. At times, nitrate plus nitrite concentrations may be greater than 10 mg/L.

These high nutrient levels may contribute to abundant algal and periphyton growths in the streams. If so, they may be accompanied by large diel swings in dissolved oxygen and pH. Dissolved oxygen values as low as 4.0 mg/L and pH values as high as 11 pH units may occur. Our instrument calibrations will need to bracket these values.

For the specific constituents we will be measuring, the data quality objectives are listed in Table 6.

Table 6a. – Data Quality Objectives for the Quittapahilla Watershed Water-Quality Monitoring Program -- Field Measurements.

Parameter	Expected range	Minimum reporting limit	Accuracy (+/-)	Precision (+/-)	Resolution (+/-)
Specific conductance	100 – 800 µS/cm	1 µS/cm	5 µS/cm	10 µS/cm	5 µS/cm
pH	4 – 11 pH units	0.5 pH units	0.2 pH units	0.2 pH units	0.1 pH units
Dissolved oxygen	4 – 18 mg/L	0.2 mg/L	0.2 mg/L	0.2 mg/L	0.1 mg/L
Water temperature	0 - 30 °C	0.2 °C	0.2 °C	0.2 °C	0.2 °C
Turbidity	0 – 100 FNU	1 FNU	2 %	0.1 FNU	0.1 FNU

Table 6b. – Data Quality Objectives for the Quittapahilla Watershed Water-Quality Monitoring Program -- Laboratory Measurements.

Parameter	Expected range	Minimum reporting limit	Accuracy (+/-)	Precision (+/-)	Resolution (+/-)
Specific conductance	100 – 800 µS/cm	1 µS/cm	5 µS/cm	10 µS/cm	5 µS/cm
pH	4 – 11 pH units	0.5 pH units	0.2 pH units	0.2 pH units	0.1 pH units
Alkalinity	20 – 600 mg/l	0.1 mg/L	5 mg/L	5 mg/L	5 mg/L
Total suspended solids	0 – 500 mg/L	2 mg/L	~ 10 %	~ 10 %	~ 10 %
Total dissolved solids	20 – 600 mg/L	2 mg/L	2 mg/L	2 mg/L	2 mg/L
Total hardness	20 – 500 mg/L	0.11 mg/L	1 mg/L	1 mg/L	1 mg/L
Total organic carbon	<1 – 10 mg/L	0.5 mg/L	1 mg/L	1 mg/L	1 mg/L

Table 6c. – Data Quality Objectives for the Quittapahilla Watershed Water-Quality Monitoring Program -- Nutrients.

Parameter	Expected range	Minimum reporting limit	Accuracy (+/-)	Precision (+/-)	Resolution (+/-)
Total nitrogen	1 – 20 mg/L	0.064 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L
Dissolved nitrogen	1 – 20 mg/L	0.064 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L
Total ammonia nitrogen	0.01 – 2 mg/L	0.02 mg/L	0.01 mg/L	0.01 mg/L	0.01 mg/L
Dissolved ammonia nitrogen	0.01 – 2 mg/L	0.02 mg/L	0.01 mg/L	0.01 mg/L	0.01 mg/L
Total nitrate + nitrite nitrogen	1 – 20 mg/L	0.04 mg/L	0.02 mg/L	0.02 mg/L	0.02 mg/L
Dissolved nitrate + nitrite nitrogen	1 – 20 mg/L	0.04 mg/L	0.02 mg/L	0.02 mg/L	0.02 mg/L
Total phosphorus	10 – 1500 µg/L	10 µg/L	10 µg/L	10 µg/L	10 µg/L
Dissolved phosphorus	10 – 1500 µg/L	10 µg/L	10 µg/L	10 µg/L	10 µg/L
Dissolved orthophosphate phosphorus	10 – 1500 µg/L	10 µg/L	10 µg/L	10 µg/L	10 µg/L

Table 6d. – Data Quality Objectives for the Quittapahilla Watershed Water-Quality Monitoring Program -- Major Ions.

Parameter	Expected range	Minimum reporting limit	Accuracy (+/-)	Precision (+/-)	Resolution (+/-)
Calcium, total	10 – 100 mg/L	0.03 mg/L	2 mg/L	2 mg/L	2 mg/L
Sodium, total	5 – 100 mg/L	0.2 mg/L	1 mg/L	1 mg/L	1 mg/L
Magnesium, total	0 – 18 mg/L	0.01 mg/L	0.2 mg/L	0.2 mg/L	0.1 mg/L
Potassium, total	0 - 20 mg/L	1 mg/L	0.2 mg/L	0.2 mg/L	0.1 mg/L
Chloride, total	0 – 250 mg/L	0.5 mg/L	0.5 mg/L	0.5 mg/L	0.5 mg/L
Bromide, total	0 – 5 mg/L	0.05 mg/L	0.1 mg/L	0.1 mg/L	0.1 mg/L
Sulfate, total	0 – 250 mg/L	1 mg/L	2.0 mg/L	2.0 mg/L	2.0 mg/L

Table 6e. – Data Quality Objectives for the Quittapahilla Watershed Water-Quality Monitoring Program -- Metals.

Parameter	Expected range	Minimum reporting limit[1,2]	Accuracy (+/-)	Precision (+/-)	Resolution (+/-)
Total aluminum	0 – 400 µg/L	200 µg/L	15%	20%	Not known
Total copper	0 – 20 µg/L	4.0 µg/L	15%	20%	Not known
Total iron	0 – 500 µg/L	20 µg/L	15%	20%	Not known
Total lead	0 – 5 µg/L	1 µg/L	15%	20%	Not known
Total manganese	0 – 100 µg/L	10 µg/L	15%	20%	Not known
Total nickel	0 – 50 µg/L	4 µg/L	15%	20%	Not known
Total zinc	0 – 50 µg/L	10 µg/L	15%	20%	Not known

[1]Estimated. Minimum reporting limits are sample dependent and may vary as the sample matrix varies.
[2]The values listed in the table are from U.S. EPA (1994a) and U.S. EPA (1994b).

Data Quality Indicators

There are several indicators that will help us identify the quality of our data. For example, we can evaluate precision, bias, accuracy, comparability, and measurement range.

Precision -- Precision defines how closely a measurement can be reproduced. For our work, we will take replicate samples in the field to evaluate the precision of our field protocols. We will also submit split samples to the lab to evaluate the precision of the laboratory analyses. Precision is measured by relative percent difference (RPD). For our work a relative percent difference of 5% will be acceptable for all constituents except for total suspended sediment and ammonia nitrogen. Total suspended sediment is a problematic constituent in the laboratory and we will establish a relative percent difference of 10% as acceptable. Ammonia nitrogen is normally present in such low concentrations that a 5% difference of a low concentration would likely be a very, very small concentration that could easily be exceeded. Therefore, for ammonia nitrogen, a relative percent difference for replicate samples of 20% will be acceptable.

For our stream discharge measurements, we will judge our precision by two concurrent discharge measurements at one location. Two of our volunteers will make a discharge measurement at the same time and at the same location. We will compare the results using the RPD statistic. An RPD of 10% or less will be acceptable.

Bias -- Bias refers to whether the data are swayed or skewed. For the Quittapahilla Watershed Monitoring Program we have selected our sampling stations in a non-random manner. Rather, these sampling locations are meant to provide characterization of a particular geographic region (sub-watershed) of the watershed. That is, we have a non-randomized sampling design. So, it is a foregone conclusion that these results will be biased. But, we must be cognizant of bias resulting from calibration errors, interferences, and sample contamination.

We will, however, be able to evaluate bias in our selection of sampling dates. Ideally, we will collect our water-quality samples covering the entire hydrograph. That is, we hope to sample during low flow, medium flow, and high flow. Frequently, sampling efforts favor taking samples during low flow, on a nice sunny day. This is particularly true for volunteer monitoring programs. We want to avoid that. To test whether there is bias in our sampling times. We will prepare a distribution of daily streamflows (from the continuous streamflow component of our program) and compare our sampled flows to this population of flows.

Accuracy -- Accuracy represents the degree of confidence in a measurement. Normally, accuracy is evaluated by submitting a sample with a known value for the constituent in question, and then comparing the lab value for that constituent with the known value. This is typically accomplished using standard reference samples, perhaps from the U.S. EPA or from the National Institute of Standards and Technology. But, these standard reference samples cost money and we are volunteer organizations with limited financial resources. If we are unable to purchase standard reference materials, then we will rely on the routine lab evaluation procedure of the Pennsylvania DEP lab. The DEP lab is certified under the National Environmental Laboratory Accreditation Program (NELAP). In this program, the lab analyzes blind samples for the constituents of interest and reports their results to the NELAP. Accreditation follows if the results are acceptable.

For our stream discharge measurements, we will ask our volunteers to measure stream discharge manually at the Quittapahilla Creek near Bellegrove (Station Q2). This site is a USGS streamflow monitoring station. We will compare the value obtained by our volunteers with the value obtained from the USGS. The value from the USGS will be considered as accurate. Our manual measurements within 10% of the USGS value will be considered as acceptable for accuracy.

Comparability – Historically, other organizations have collected water-quality data from the Quittapahilla Creek Watershed. (See section on Existing data.) We will judge our results against these historical data to make sure our data are within the limits of historical data.

Measurement Range -- We expect that some of our targeted constituents will exhibit a large range in concentrations. (See section on Data Quality Objectives.) Measurement range is unique to each instrument used to make the measurement. For our work, all our field instruments have ranges that should cover any occurrence of the constituent that we encounter in the Quittapahilla Watershed.

Training and Specialized Expertise

Training

The Quittapahilla Watershed Water-Quality Monitoring Program is a volunteer-oriented effort. The individuals collecting the samples and conducting the stream-discharge measurements are volunteers. They have no background in water-quality assessments. But, several of our volunteers are members of the local chapter of Trout Unlimited. They are familiar with stream hydrology from an avocational perspective and they are comfortable wading in streams. They are eager to learn and committed to making improvements in the water quality of the Quittapahilla Creek. Some of our volunteers have construction experience which will be key in installing our streamflow-monitoring equipment.

To make up for the lack of water-quality experience of our volunteers, we will provide training to educate them about the tasks they will perform. The training will include two classroom style sessions, one on stream discharge measurements and one on water-quality sampling. These will be followed by corresponding hands-on field experiences to reinforce the classroom instruction. In addition, each volunteer will be given an opportunity to demonstrate his or her knowledge of the material by completing a written test covering each of the classroom sessions. These tests will be designed to reinforce the classroom instruction.

Also, at one location, we will conduct concurrent field measurements of stream discharge by two of our sampling teams. We expect the two measurements to agree with each other within 10 percent. If the measurements do not agree, we will provide guidance to correct any errors.

For the in-situ water-quality work, representatives from the Pennsylvania Department of Environmental Protection will provide a demonstration of the calibration and deployment of the water-quality sondes. DEP personnel will also train our volunteers on the use of the Aquarius data management software.

Specialized Expertise

The coordinator of the Monitoring Program, Dr. Kent Crawford, is an experienced water-quality professional. He is planning and organizing the Monitoring Program, training the volunteers, and providing oversight. He was employed by the U.S. Geological Survey, Water Resources Division, for more than three decades. For much of his tenure with the USGS, he served as the Water Quality Specialist for the Pennsylvania Water Science Center. Dr. Crawford is now retired and is available to support the Quittapahilla Watershed Monitoring Program.

Documents and Records

All original paper documents and electronic records will be maintained by the Monitoring Coordinator at his home at 1115 Stonegate Road, Hummelstown, Pennsylvania. Paper documents will be photocopied and these copies will be provided to the QWA Secretary for back-up storage. Electronic files will be stored on a personal computer and backed up to an external storage device. Likewise, a copy of these electronic records will be provided to the QWA secretary for storage at a separate location. Electronic files will also be housed on the QWA web pages under the Monitoring heading and available to everyone.

A field data form (Appendix A) will be filled out for each stream discharge measurement and for each water-quality sample collected. These forms will be similar to the PaDEP field forms. The volunteer monitors who make the measurements or collect the samples will be responsible for filling out the forms and each form will be checked by the Monitoring Coordinator and stored at 1115 Stonegate Road, Hummelstown, Pennsylvania. Copies of the field forms will be provided to the QWA Secretary.

Each sample that is sent to the DEP laboratory for chemical analysis will be accompanied by a Laboratory Submission Sheet. These sheets will be retained by the DEP Laboratory.

Existing Data

Two major reports have provided invaluable information about the Quittapahilla Creek Watershed. These are Quittapahilla Creek Watershed Assessment, Volume 1 – Findings Report, and Volume 2 – Restoration and Management Plan (Clear Creeks Consulting, 2006a and 2006b). These comprehensive documents include watershed characteristics, hydrologic analyses, assessments of stream morphology, ecological assessments, and, most importantly, water-quality evaluations. The water-quality sampling included stormflow sampling at ten locations within the watershed. Analyses included the primary focus of the planned Monitoring Program, nutrients, turbidity, and total suspended solids. The water-quality sampling was conducted in 2003, some 17 years prior to today (2020). A sediment discharge study was also conducted as part of the overall assessment. Results of that work are provided in Skelly & Loy and Clear Creeks Consulting (2005). Our planed Monitoring Program will not be as comprehensive as the 2003 work. But, the 2003 data will provide a benchmark that can be used as a comparison for the planned program.

Another important data source is the Total Maximum Daily Loads report for the Quittapahilla Creek Watershed (Pennsylvania Department of Environmental Protection, 2000). The water-chemistry data for this report were available from a one-time watershed-wide sampling conducted in 1989. These data also may be used for comparison to the data that we will collect in our volunteer Monitoring Program.

The Susquehanna River Basin Commission (SRBC) also collects water-quality data in the Quittapahilla Creek Watershed. Their data are conveniently housed on line in their Water Quality Portal and accessible to anyone having an internet connection at:

https://www.srbc.net/portals/water-quality-projects/

The SRBC data have been collected through the Remote Water Quality Monitoring Network and the Lower Susquehanna Subbasin Survey.

The Remote Water Quality Monitoring Network collects continuous data for the Quittapahilla Creek on water temperature, specific conductance, pH, dissolved oxygen, and turbidity. The monitoring location is near Syner, PA.

The Lower Susquehanna Subbasin Survey collects samples periodically and the analytes include field measurements, nutrients, major ions, metals, and a few other constituents such as suspended sediment. These samples are also collected from the mainstem of the Quittapahilla Creek near Syner, PA.

Finally, in the mid-1990s, the U.S. Geological Survey conducted water-quality sampling at several locations in the Quittapahilla Creek Watershed as part of the National Water Quality Assessment. Samples were collected at Killinger Creek, Snitz Creek, Beck Creek, and Bachman Run. The Bachman Run site was part of a carbonate geology assessment and numerous samples were collected at that location. The data available include field measurements, nutrients, major ions, pesticides, and suspended sediment. Data from these samples are available on line through the National Water Information

System (NWIS) Mapper. This is a geographic-based portal to the water-quality data and can be accessed at:

https://maps.waterdata.usgs.gov/mapper/

Data Collection Methods

Stream Discharge

Stream discharge will be measured using the velocity-area method. Basically, this method measures the cross-sectional area of a stream and then measures the velocity of the water in the stream. The product of the cross-sectional area (in ft^2) times the velocity (in ft/s) yields the discharge (in ft^3/s or cfs). Cross-sectional area will be calculated by multiplying the width of the stream times the depth in feet. Velocity is measured using a velocity meter.

But, streams have variable cross-sectional profiles and varying velocities within one cross section. One velocity measurement would not adequately represent the entire width of the stream. Therefore, a stream cross section will be subdivided into multiple sections. The width and depth of each section will be measured and the velocity within each section will be measured. Using these measurements, a discharge can be determined for each stream section. The total discharge for the stream is the sum of the discharges for all the sections across the width of the stream.

The velocity of a stream also varies with the depth of the stream. Therefore, the vertical location of the velocity measurement is critical. For the pygmy current meter, we will use the six-tenths depth location in the vertical column for streams having a depth of 1.5 feet or less. That is, the velocity will be measured at 0.6 X depth of the stream. For streams having a depth of greater than 1.5 feet, we will use the two-point method with one velocity measurement taken at 0.2 X depth and a second at 0.8 X depth. These two velocities will be averaged to provide the velocity used for the discharge calculation for that stream section. These methods follow the guidance in Turnipseed and Sauer (2010), with the exception noted in the following paragraph.

For the Quittapahilla Creek and its tributaries, we will subdivide the stream into ten sections for each discharge measurement. This is contrary to the U.S. Geological Survey recommendation of 20 sections for each streamflow measurement (Turnipseed and Sauer, 2010). However, for the low-gradient, valley streams in the Quittapahilla Creek Watershed, flows are somewhat uniform from bank to bank. Certainly, they are not laminar, but there is not the wild variation seen in some streams. Further, the streams where our monitoring stations are located are small, most having widths on the order of 30 feet. So, having ten measuring points in a cross section would mean that there is a measuring point approximately every three feet across the stream. At this density, coverage would be quite thorough and 10 sections would seem to be adequate. See “Data Quality Indicators” section of this QAPP for additional information.

A field data sheet will be completed for each stream discharge measurement (Appendix A).

In-Situ Water-Quality Measurements

The values for certain water-quality characteristics change quickly once a sample is collected. These characteristics include stream temperature, specific conductance, pH, and dissolved oxygen. For these characteristics, we will take measurements in-situ during a water-quality sampling event. That is, these measurements will be done in the field rather than in the laboratory. The measurements will be made using multi-parameter water-quality instruments (sondes). We have two of these instruments (sondes) (Manta II made by the Eureka Company) available for our use. Calibration of these instruments will be performed at the beginning of each sampling day and will follow manufacturer's guidelines. Results of the calibrations will be recorded in the log book for each instrument.

Discrete Water-Quality Samples

Collection and handling of our water-quality samples will closely follow the guidelines from the PaDEP (Shull, 2017). Samples will be collected in pre-cleaned high-density polyethylene bottles provided by the PaDEP Bureau of Laboratories. These bottles will be stored in clean plastic bags until ready for use in the field. Each bottle will be rinsed three times with ambient water prior to collecting the sample. The person collecting the sample will wear clean, single-use, disposable nitrile gloves throughout the sampling process.

Samples will be collected at mid depth of the stream, in the thalweg, if possible. To avoid collecting surface debris, the collector will insert the bottle in the stream and then remove the bottle cap once the bottle is underwater. This technique also avoids other potential contamination sources.

Some samples will require filtration in the field. Pre-cleaned single-use field filtration kits will be used for this task. Filters will have a pore size of 0.45 µm and will be rinsed with deionized ultrapure water prior to filtering the sample.

Preservatives will be added as required. For nutrient samples, 2.0 ml of sulfuric acid will be added using a pipette to reduce the pH of the sample to < 2.0 pH units. For metals, 2.0 ml of nitric acid will be added using a pipette to reduce the pH of the sample to < 2.0 pH units. All samples will be cooled on ice to 4^{o} Celsius.

Sample bottles will be labeled as indicated in Table 7.

Table 7.—Information required for labels on the sample bottles.

Required label	Notes
Collector number	Assigned by DEP
Sequential sample number	Three digits beginning with 001 each day
Station number	Q1, Q2, S1, BK1, BM1, or K1
Date	Format = mm/dd/yyyy
Time (24-hour clock)	Eastern Standard Time (not EDT)
Test to be conducted	Nutrients, major ions, metals, TSS
Preservative	H_2SO_4, HNO_3, none
Filtered or Unfiltered	

Once the samples are collected, the sample bottles will be placed in coolers with ice and volunteers will transport the samples to the PaDEP laboratory at 2575 Interstate Drive, Harrisburg, Pennsylvania for analysis. A sample submission sheet (Appendix B) to guide the laboratory staff will accompany the samples. The sample submission sheet will be inserted into a zipper-seal plastic bag and attached to the inside of the cooler lid using mailing tape.

In addition to the sample submission sheet, a field data sheet will be completed for each water-quality sample (Appendix C). The field data sheet will be retained by QWA/DFTU personnel as a record of the sample.

Continuous Monitoring

We anticipate conducting a limited number of special projects that will make use of continuous monitoring. For these studies, we will use water-quality instruments (sondes) capable of making multiple environmental measurements at pre-determined time intervals over a period of several days. The measurements of interest include water temperature, specific conductance, pH, and dissolved oxygen. Calibration of the sondes will follow manufacturer's guidelines and the results of the calibrations will be recorded in a log book for each sonde.

Deployment of the sondes will be dependent on the purpose of the monitoring. Possible purposes for continuous monitoring could include:

- Studies of maximum daytime stream temperatures relative to the temperature tolerance limit of trout
- Studies of temperature spikes during summer storms
- Diel studies of dissolved oxygen
- Studies to evaluate daily pH swings
- Studies of water quality during high-flow events

Sampling Equipment

Stream Discharge Equipment

The central piece of equipment for measuring streamflow (discharge) is a velocity meter. The meter is attached to a top-set wading rod which is marked in feet and tenths of feet. The top-set feature allows the user to adjust the depth of the meter as required for making a velocity reading. An electrical lead runs from the current meter to the top of the wading rod where a headphone is attached. The headphone allows the user to count electrical clicks which correspond to revolutions of the cups of the meter. The number of revolutions can then be converted to velocity in feet per second. We have three Pygmy velocity meters (Figure 3) available for our use. We have two top-set wading rods and two headsets available as well.

Figure 3. – A Pygmy velocity meter.

A stream discharge measurement also requires a measuring device to pinpoint the locations across the width of a stream where velocity measurements should be taken. We have two 100-foot open reel fiberglass tapes for these measurements.

Five of our six monitoring stations will be equipped with a pressure transducer and data logger (Figure 4) that will be situated near the bottom of the stream and will record water pressure. Water pressures will be logged every 15 minutes which will provide a "continuous" record of water pressure. Because the water pressure is dependent on the depth of the water, this will give us a continuous reading of water depth or water level. Each station will also have a staff plate (Figure 5) which is used to measure water level. We will correlate water-level readings from the staff plate with simultaneously-recorded water pressures. In addition, we will take several manual stream-discharge measurements at each station and each time we take a stream discharge measurement, we will record the staff-plate reading. Then, we will be able to develop rating curves (gage height versus stream discharge) (See Figure 2). From the rating curves, we can construct a continuous record of streamflow.

Figure 4. – A pressure transducer and data logger.

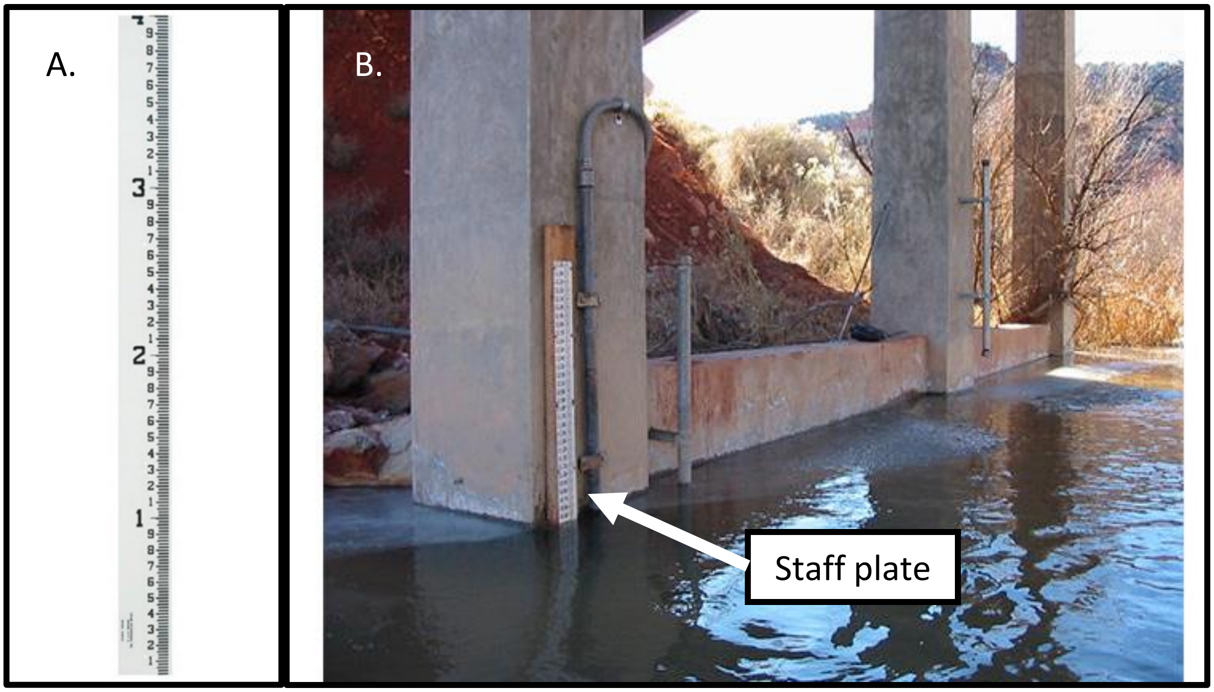

Figure 5. – A. Staff plate marked in feet and tenths of feet. B. Staff plate mounted on bridge piling.

Our sixth monitoring station is a USGS streamflow-monitoring site and we will use data from the USGS for our purposes. Therefore, we will not need any streamflow equipment for that site.

Our pressure transducers come with a reading for barometric pressure as well as absolute pressure. Therefore, the correction for atmospheric pressure is accounted for in the logger software. We will not need a separate monitor for atmospheric pressure.

In-Situ Water-Quality Sampling Equipment

The values for certain water-quality characteristics change quickly once a sample is collected. These characteristics include stream temperature, specific conductance, pH, and dissolved oxygen. For these characteristics, we will take measurements in-situ during each water-quality sampling event. The measurements will be made using multi-parameter water-quality instruments (sondes). We have two of these instruments (sondes) made by the Eureka Water Probes company available for our use. Calibration of these instruments will be performed at the beginning of each sampling day and will follow manufacturer's guidelines.

Discrete Water-Quality Sampling Equipment

Our routine water-quality samples will be collected by our volunteers. They will wade into the stream and collect a “grab” sample as described in the previous section on Data Collection Methods. No special equipment is required other than the sample bottles and nitrile gloves to be worn by the collector.

Some samples will require filtration in the field. Pre-cleaned, single-use field filtration units will be used for this task. Filters will have a pore size of 0.45 µm and will be rinsed with deionized “ultrapure” water prior to collecting the sample.

<u>Continuous Monitoring Equipment</u>

We anticipate conducting a limited number of special projects that will make use of continuous monitoring. For these studies, we will use water-quality instruments (sondes) capable of making multiple environmental measurements at pre-determined time intervals over a period of several days or weeks (Figure 6). These readings are stored in the internal memory of the sonde. The measurements of interest include water temperature, specific conductance, pH, and dissolved oxygen. Calibration of the sondes will follow manufacturer’s guidelines and the results of the calibrations will be recorded in a log book for each sonde.

Figure 6. Water quality sonde with hand held control unit.

Analytical Methods

Laboratory analyses will be performed by the Bureau of Laboratories, PaDEP, Harrisburg, Pennsylvania. This is a NELAC accredited lab that undergoes an annual quality evaluation. The lab analyzes hundreds of samples annually for the constituents of interest to the Quittapahilla Watershed Water-Quality Monitoring Program. Table 8 lists the constituents of interest, the method of analysis, and other key information.

Table 8a. – Target parameters for the Quittapahilla Watershed Water-Quality Monitoring Program – Field Measurements

Parameter	Analytical method	Minimum reporting limit	Sample volume (mL)	Container	Preservative
Specific conductance	SM 2510B	1 µS/cm	In-situ	None	None
pH	SM 4500H-B	0.5 pH units	In-situ	None	None
Dissolved oxygen	SM 4500-O	0.2 mg/L	In-situ	None	None
Water temperature	SM 2550	0.2 ^{o}C	In-situ	None	None
Turbidity	US EPA 180.1	5 NTU	In-situ	None	None

Table 8b. – Target parameters for the Quittapahilla Watershed Water-Quality Monitoring Program – Laboratory Measurements.

Parameter	Analytical method	Minimum reporting limit	Sample volume (mL)	Container	Preservative
Specific conductance	SM 2510 B	1 µS/cm	500 mL	HDPE	Chill @ 4^{o}C
pH	SM 4500 H-B	0.5 pH units	500 mL	HDPE	Chill @ 4^{o}C
Alkalinity	SM 2320 B	1 mg/L	500 mL	HDPE	Chill @ 4^{o}C
Total Suspended solids	USGS-I-3765	2 mg/L	500 mL	HDPE	Chill @ 4^{o}C
Total dissolved solids	USGS-I-1750	2 mg/L	500 mL	HDPE	Chill @ 4^{o}C
Total hardness	SM 2340 A+B	0.11 mg/L	500 mL	HDPE	Chill @ 4^{o}C
Total organic carbon	SM 5310 C	0.5 mg/L	500 mL	HDPE	Chill @ 4^{o}C

Table 8c. – Target parameters for the Quittapahilla Watershed Water-Quality Monitoring Program – Nutrients.

Parameter	Analytical method	Minimum reporting limit	Sample volume (mL)	Container	Preservative
Total nitrogen	SM 4500N-ORG	0.064 mg/L	125	HDPE	Chill @ 4°C 2 mL H_2SO_4
Dissolved nitrogen	SM 4500N-ORG	0.064 mg/L	125	HDPE	Chill @ 4°C 2 mL H_2SO_4
Total ammonia nitrogen	EPA 350.1	0.02 mg/L	125	HDPE	Chill @ 4°C 2 mL H_2SO_4
Dissolved ammonia nitrogen	EPA 350.1	0.02 mg/L	125	HDPE	Chill @ 4°C 2 mL H_2SO_4
Total nitrite + nitrate nitrogen	EPA 353.2	0.04 mg/L	125	HDPE	Chill @ 4°C 2 mL H_2SO_4
Dissolved nitrite + nitrate nitrogen	EPA 353.2	0.04 mg/L	125	HDPE	Chill @ 4°C 2 mL H_2SO_4
Total phosphorus	EPA 365.1	10 µg/L	125	HDPE	Chill @ 4°C 2 mL H_2SO_4
Dissolved phosphorus	EPA 365.1	10 µg/L	125	HDPE	Chill @ 4°C 2 mL H_2SO_4
Dissolved orthophosphate	EPA 365.1	10 µg/L	125	HDPE	Chill @ 4°C 2 mL H_2SO_4

Table 8d. – Target parameters for the Quittapahilla Watershed Water-Quality Monitoring Program – Major Ions.

Parameter	Analytical method	Minimum reporting limit	Sample volume (mL)	Container	Preservative
Calcium, total	EPA 200.7	0.03 mg/L	500 mL	HPDE	Chill @ 4°C
Sodium, total	EPA 200.7	0.2 mg/L	500 mL	HPDE	Chill @ 4°C
Magnesium, total	EPA 200.7	0.01 mg/L	500 mL	HPDE	Chill @ 4°C
Potassium, total	EPA 200.7	1 mg/L	500 mL	HPDE	Chill @ 4°C
Chloride, total	EPA 300.0	0.5 mg/L	500 mL	HPDE	Chill @ 4°C
Bromide, total	EPA 300.0	0.05 mg/L	500 mL	HPDE	Chill @ 4°C
Sulfate, total	EPA 300.0	1 mg/L	2 x 500 mL	HPDE	Chill @ 4°C

Table 8e. – Target parameters for the Quittapahilla Watershed Water-Quality Monitoring Program – Metals.

Parameter	Analytical method	Minimum reporting limit	Sample volume (mL)	Container	Preservative
Total aluminum	EPA 200.7	200 µg/L	125 mL	HDPE	Chill @ 4°C 2 mL HNO_3
Total copper	EPA 200.8	4.0 µg/L	125 mL	HDPE	Chill @ 4°C 2 mL HNO_3
Total iron	EPA 200.7	20 µg/L	125 mL	HDPE	Chill @ 4°C 2 mL HNO_3
Total lead	EPA 200.8	1 µg/L	125 mL	HDPE	Chill @ 4°C 2 mL HNO_3
Total manganese	EPA 200.7	10 µg/L	125 mL	HDPE	Chill @ 4°C 2 mL HNO_3
Total nickel	EPA 200.7	4 µg/L	125 mL	HDPE	Chill @ 4°C 2 mL HNO_3
Total zinc	EPA 200.7	10 µg/L	125 mL	HDPE	Chill @ 4°C 2 mL HNO_3

Quality Assurance

The first priority for our classroom training will be safety. Volunteers will each be provided a set of safety precautions that are to be followed for any Quittapahilla Watershed activity. Safety will be emphasized from the outset and will be emphasized in all we do.

All volunteers who participate in sample collection or streamflow measurements will be required to attend both a classroom training session and a field training session.

Classroom training – Stream Discharge

The classroom training for stream discharge measurements will cover stream discharge basics including the importance of discharge, the relation between discharge and water quality, and methods for measuring discharge. Steps for installing a stream-discharge gauging station will be covered. The Quittapahilla Watershed Monitoring Program will use Pygmy velocity meters for our discharge measurements and care and use of the current meters will be addressed. The concept of a hydrograph will be introduced and the steps for constructing a stage-discharge relation (a rating curve) (see Figure 2) will be covered.

Field Training – Stream Discharge

The field training for stream discharge will consist of a demonstration by an experienced hydrologist, followed by an opportunity for each volunteer to conduct a complete streamflow measurement in the field. The field measurement will be repeated by other volunteers as an accuracy check. Volunteers will be required to assemble, disassemble, clean, and store the current meter. Each volunteer will fill out the required field form and calculate the total discharge for the stream. We will compare the results of the measurements taken by our volunteers with those of other volunteers. Final discharge values for all volunteers should agree with in 10 percent.

Classroom Training – Water Quality

Classroom training for water quality sampling will begin with an explanation of the overall objectives for the monitoring project and the need to collect quality-assured samples. It will include a discussion of natural variations in water quality and the need to have data that are as accurate as possible.

The concepts of quality control for water-quality samples will be provided to include sources of contamination, avoiding contamination, and checks on the quality of the sample-collection process. This will include introductions of sample blanks, replicates, and standard reference materials.

Both the classroom training and the field training will be conducted by Dr. Kent Crawford, an environmental scientist with over 40 years of experience.

Field Training – Water Quality

The water-quality field training will include a hands-on session for our volunteers. Each participant will have an opportunity to demonstrate, in a field setting, the sample-collection techniques that have been discussed in the classroom training session. This will include wearing disposable gloves, bottle handling, equipment assembly, equipment rinse, collecting the sample, filtration and preservation, sample storage, sample delivery to the lab, and equipment cleaning and storage following the sample collection. The work of each volunteer will be critiqued by the project coordinator and by fellow volunteers.

Testing

At the end of both classroom training sessions, the material presented will be reinforced using a written test. Each of the volunteers will have a chance to demonstrate his or her understanding of the material presented. The tests will be constructed so as to reinforce the classroom material.

Quality Control

Field Quality Control

Our project will use multi-parameter research-grade field water-quality instruments (sondes) for in-situ testing associated with water-quality samples and for long-term deployment. These instruments measure water temperature, specific conductance, dissolved oxygen, pH, and turbidity.

For each water-quality instrument, a log book will be maintained to record the historical performance of the instrument for each of the calibrations. These log books will document deviations from calibration expectations and will provide a record of maintenance activities for that instrument. For example, whenever new probes are installed, this will be recorded in the log book.

At the beginning of each sampling event, each instrument will be calibrated according to manufacturer's guidance. These calibrations can be done in a laboratory (or home) setting for all the parameters except for the dissolved-oxygen calibration, which must be done at the sampling site. Fresh buffers and standards will be used for each calibration.

For the streams we will be monitoring, trout fishing is an important activity. Yet, there is a question as to whether the temperature regime of the streams is cold enough to support trout livelihood throughout the summer. So for our objectives, temperature will be a critical measure. Therefore, we will subject all our thermistors to a water bath at two temperature levels (4 degrees Celsius and approximately 30 degrees Celsius). These temperatures will be verified with a National Institute of Standards and Technology (NIST) verified thermometer and deviations from the NIST standard will be noted and the record will be adjusted accordingly.

Quality Control Samples

We will submit quality control samples to the laboratory to check on our sampling protocol and how well our volunteers are performing their sampling tasks. Field blanks will indicate whether we are introducing any contamination in our samples. Equipment blanks will indicate whether our cleaning procedures are adequate. We anticipate that at least 10 percent of our sample total will be quality control samples.

Data Management

Analytical data from the PA DEP laboratory will be housed at DEP and reported to the Quittapahilla Watershed Water Quality Monitoring Program. The Quittapahilla group will then transfer these data to Microsoft Excel data files for storage and analysis.

Field data measured using the Manta sondes will be stored initially on the Archer control unit that is part of the Eureka monitoring system. Those data will then be ported into the Microsoft Excel data files maintained by the Quittapahilla Watershed Water Quality Monitoring Program.

Reporting

We anticipate producing a written summary data report following each year of monitoring. The report will provide an overview of the year's activities and will include some basic statistics for our water-quality data. The report we envision will be supported with ample tabular and graphic displays describing our data. Eventually, a trends analysis may be attempted, but this advanced reporting can be achieved only after several years of data are available.

Each special study that we conduct will have its own accompanying report, prepared for submission to a scientific journal. These reports would be authored or co-authored by our summer student researchers.

Data Review

Dr. Kent Crawford, Monitoring Coordinator, will provide the data review function for the Monitoring Program. Dr. Crawford is a member of the Board of Directors for the Quittapahilla Watershed Association and is a retired environmental scientist. During his career, Dr. Crawford was the Water-Quality Specialist for the Pennsylvania Water Science Center of the U.S. Geological Survey. His assignments included laboratory coordinator, water-quality instructor, and data reviewer. His review functions for the Monitoring Program will cover all aspects of the Program including planning activities, training, water-quality sampling, data management, and report preparation.

Field data sheets and laboratory submission sheets will be reviewed periodically for completeness and accuracy. Likewise, instrument calibration forms will be checked periodically. These checks will be performed more frequently at the beginning of the data collection project to make sure our volunteers are following established protocols.

The data review process will begin as data are returned from the laboratory. As analytical data are returned from the lab, we will import them into a Microsoft Excel file for data checking, analysis, and back-up storage. Then we will use Excel to produce graphs for each constituent. This will allow us to identify data outliers that need to be checked for accuracy. This process will also allow us to screen for erroneous values (for example a pH of 76 as opposed to 7.6).

Blank samples, replicate samples, and standard reference samples will be reviewed as they are returned from the laboratory. Contamination will be identified and investigated. Deviations from known values of constituents will be flagged and discussed with laboratory personnel.

Cation-anion balance will be calculated for each water-quality sample to confirm that lab analyses are correct. The ion balance (in meq/L) represents the total dissolved-cation concentration minus the total dissolved-anion concentration divided by the total concentration of ions dissolved in solution. The total cation concentration is the sum of calcium, magnesium, sodium, and potassium; the total anion concentration is the sum of acid-neutralizing capacity, chloride, fluoride, and sulfate. Inorganic nitrogen species (nitrite plus nitrate) are likely to be quite high in the Quittapahilla Creek Watershed and will be included in the sum of the anions. Ion balances within the +/- 10 percent range will indicate that the major-ion analyses are of good quality. Anything outside that range will be flagged and traced for possible error. Hem has pointed out that ion balances outside of the 10 percent range may be attributable to unmeasured constituents such as organic anions, nutrients, and trace metals (Hem, 1985).

For each sampling station, we will also prepare a graph of the measured specific conductance against the total dissolved solids concentration. Because the specific conductance is a summation of all the dissolved ions in solution, this graph should result in a straight line. The slope of the line may vary from one station to the next, depending on the chemical makeup of the water at that station. But, each graph should result in a straight line. If the line is not straight or if there are outliers, then something is amiss and the source of the error will be investigated.

If obviously inaccurate data are found or data that do not meet the data quality objectibves, Dr. Crawford will consult with the lab in an attempt to locate the source of the error.

In addition, all of our data will be shared with the PaDEP for their review and use.

Key Contacts

Our volunteers are the backbone of our Monitoring Program. Their service and attention to detail is greatly appreciated. We will endeavor to keep them all in the loop for all monitoring decisions and activities. Also, there are several individuals who be updated on the activities of our Monitoring Program. Specifically, key individuals in our partner organizations deserve periodic updates and continuing communication. Figure 7 provides a list of those individuals as of July 2020.

Our Volunteers

- Howard Bixler
- Russ Collins
- Joe Connor
- David Ethridge
- Dale Mackley
- Trip McGarvey
- Michael Schroeder
- Stephen Vegoe
- Chad Weber
- Gary Zelinske

Doc Fritchey Trout Unlimited

- Russ Collins, President
- Rich DiStanislao, Vice President
- Ed O'Gorman, Past President
- Bob Pennell, Secretary
- Trip Mc Garvey, Treasurer

Quittapahilla Watershed Association

- Michael Schroeder, President
- David Lasky, President Emeritus
- Karen Feather, Board Member
- Al Wood, Board Member

Lebanon Valley College

- Stacy Goodman, Chair, Biology Department
- Rebecca A. Urban, Director of Environmental Science

LandStudies, Inc.

- Mike LaSala, Sr. Project Manager

The Lebanon Valley Conservancy

- Ned Gibble, Board President
- Chuck Wertz, Board Vice-President
- Karen Feather, Board Secretary
- Laurie Crawford, Executive Director

Pennsylvania Dept. of Environmental Protection

- Gary Walters, Chief, Division of Water Quality
- Josh Lookenbill, Chief, Monitoring Section
- Mark Hoger, Biologist II

Lebanon County Planning Department

- Julie Cheney, Executive Director

Lebanon County Stormwater Consortium

- Robin Getz, Chair
- Bryan Hoffman, Member

Lebanon County Conservation District

- Katie Doster, District Manager
- Karl Kerchner, Asst. District Mgr.
- Stephanie Harmon, Watershed Specialist

U.S. Natural Resources Conservation Service

- Mike Snyder, District Conservationist

Clear Creeks Consulting, LLC

- Rocky O. Powell

Figure 7. – Key contacts for the Quittapahilla Watershed Water-Quality Monitoring Program.

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Appendix A. Field data sheet for stream discharge measurements.

Field Data Sheet for Discharge Measurements
Quittapahilla Watershed Water-Quality Monitoring Program

Station where discharge measurement is being made: (place a check in first column)

✓	Station name	Station number
	Quittapahilla Creek at Garfield Street	Q1
	Quittapahilla Creek at Palmyra-Bellegrove Road	Q2
	Snitz Creek at Dairy Road	S1
	Beck Creek at Bricker Lane	BK1
	Bachman Run at Louser Road	BM1
	Killinger Creek at Killinger Road	K1
	Other ______________________________________	

Date: (format = MM/DD/YYYY) ______________________

Time: (Eastern Standard Time not daylight time) (format = 2400 hours) ________________

Individuals in party: ____

Staff gauge reading before measurement: ___________ Time of reading: _____________

Staff gauge reading after measurement: ___________ Time of reading: _____________

Average staff gauge reading: ___________ Meter number: _____________

Measurement notes:

Section number	Distance from REW LEW (in feet)	Section width (in feet)	Section depth (in feet)	Depth of velocity measure ment	Number of revs. (clicks)	Time (in seconds)	Velocity (from chart) (in ft/s)	Section Area (in ft^2)	Section discharge (ft^3/s)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
					Total discharge (in ft^3/s)			=	

Appendix B. Laboratory sample submission sheet.

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pennsylvania DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF LABORATORIES

PLEASE PRINT:

MULTIPLE SAMPLE SUBMISSION SHEET

Collector I.D. #	Reason Code	Cost Center	Program Code

LABORATORY USE ONLY				
pH <2?	Res. Cl?	Temp. ≤6°C?	Initials	M
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No		

Sequence Number	Date Collected	Time Collected	Sampling Location	SAC or Suite Code(s)	Additional Tests	Legal Seal Number(s)	Intact Y/N	Initials	Lab Numbe

NUMBER OF INORGANIC CONTAINERS SENT:

	# Unfiltered	# Filtered		# Unfiltered	# Filtered
# Unpreserv:			# CN:		
# N/P:			# Metals:		
# Phenol:			# TPH/O&G:		
# TOC:			# DOC		
# Fe+2:			# Sulfide:		
# Other:			# TOX:		

Verified by (lab initials):

NUMBER OF ORGANIC CONTAINERS SENT:

# Preserved		# Unpreserved			
40 mL VOA:		40 mL VOA:		500 mL Amber:	
60 mL VOA:		60 mL VOA:		20 mL scint.:	
1 L Amber:		Encore:		Other:	
PFAS Bottle:		1 L Amber:			
Other:					

Verified by (lab initials):

Additional Information:

☐ **Check Here If Com Samples**

Facility Name: ______________ Facility ID #: ______________ Alternate Contact: ______________

Sample Collector Name: ______________ Phone: ______________ How Shipped: ☐ commercial courier ☐ Hand Deliv

Chain of Custody	Print Name	Signature	Date
Relinquished by Sample Collector:			
Accepted by:			
Relinquished by:			
Received at the Bureau of Labs:		Lab Initials:	

Note: Place this Sample Submission Sheet in a sealed plastic bag. Secure the bag to the top of the lid inside the cooler.

Appendix C. Field data sheet for water-quality samples.

Field Data Sheet for Water-Quality Samples
Quittapahilla Watershed Water-Quality Monitoring Program

Station where water sample is being collected: (place a check in first column)

✓	Station name	Station number
	Quittapahilla Creek at Garfield Street	Q1
	Quittapahilla Creek at Palmyra-Bellegrove Road	Q2
	Snitz Creek at Walnut Street	S1
	Beck Creek at Bricker Lane	BK1
	Bachman Run at Louser Road	BM1
	Killinger Creek at Killinger Road	K1
	Other ______________________________________	

Date: (format = MM/DD/YYYY) ______________________

Time: (Eastern Standard Time not daylight time) (format = 2400 hours) ________________

Individuals in party: ____

Staff gauge reading: ___________ Time of staff gauge reading: _____________

Location where sample was collected:
____ Thalweg
____ Right edge of water (looking downstream)
____ Left edge of water (looking downstream)
____ Other: ___________________________

Field water-quality measurements: (Number of water quality sonde: _______________)

✓	Parameter	Reading
	Water temperature (in °C)	
	Specific conductance (in µmho/cm)	
	pH (in pH units)	
	Dissolved oxygen (in mg/L)	
	Turbidity (in NTU)	

Sample bottles collected: (place a check in first column)

✓	Analysis	Bottle	Bottle composition	Filtered?	Preservative
	Inorganics, total	2 - 500 mL	HDPE	No	Chill
	Nutrients, total	500 mL	HDPE	No	H_2SO_4, chill
	Nutrients, dissolved,	125 mL	HDPE	Yes	H_2SO_4, chill
	Nutrients, dissolved,	125 mL	HDPE	Yes	H_2SO_4, chill
	Metals, total	125 mL	HDPE	No	HNO_3, chill