DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Clean Water

DOCUMENT NUMBER: 386-3000-001

TITLE: Pennsylvania Improving Waters Program Guidelines: Documenting and Reporting Measureable, Incremental Improvements in Water Quality of Streams, Rivers and Lakes

EFFECTIVE DATE: Upon publication of notice as final in the Pennsylvania Bulletin

AUTHORITY: The Pennsylvania Clean Stream Law, 35 P.S. § 691.1 et seq.

POLICY: This policy provides guidance and procedures for identifying incremental improvement in the water quality of streams, rivers, and lakes.

PURPOSE: The purpose of these guidelines is to explain the process for Pennsylvania Department of Environmental Protection (DEP) staff and others involved in water quality monitoring who are interested in documenting and reporting measurable, incremental improvements in water quality in streams, rivers and lakes that result in progress towards an impairment free condition.

APPLICABILITY: This guidance applies to individuals who wish to contribute information that will be used to document improvements in polluted waters of the Commonwealth.

DISCLAIMER: The policies and procedures outlined in this guidance document are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements.

The policies and procedures herein are not an adjudication or a regulation. There is no intent on the part of the Department to give these rules that weight or deference. This document establishes the framework within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.

PAGE LENGTH: 20 pages
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Pennsylvania Improving Waters Program Guidelines

Executive Summary

The purpose of these guidelines is to explain the process for Pennsylvania Department of Environmental Protection (DEP) staff and others involved in water quality monitoring who are interested in documenting and reporting measurable, incremental improvements in water quality in streams, rivers and lakes that result in progress towards an impairment free condition.

The information collected through the guidelines will be used to share stories about surface waters that show incremental improvement largely due to the voluntary actions of communities in which the rivers, streams, lakes and ponds are located.

Background

Pennsylvania has a wealth of surface water resources with over 86,000 miles of streams and rivers along with 161,455 acres of lakes. These abundant water resources are protected by a variety of laws, regulations, permits, policies, and best management practices (BMPs). A subset of these water resources is afforded “Special Protection” through regulatory programs because they are of the highest quality in terms of their chemical, physical, and biological health.

DEP, natural resource agencies, county conservation districts, municipal governments, watershed organizations, and others with an interest in watershed stewardship have invested enormous effort in the implementation of pollution reduction activities and BMPs to restore and protect water resources in every county of Pennsylvania. This effort has been primarily focused on remedying non-point sources of pollution. Despite these efforts, many rivers, streams, and lakes are “impaired” or not meeting a water quality standard for aquatic life or human health protection.

According to the 2014 Integrated Report (www.dep.pa.gov, search Water Quality), 16,882 stream miles are impaired. The two largest sources of pollutants are agriculture and abandoned mine drainage. The most frequently named pollutants are siltation and metals. Urban runoff and storm sewers are major sources of pollutants in metropolitan areas. In addition, 37,759 lake acres are impaired. The leading pollutant source to lakes is agriculture and the most frequently named parameters of concern are nutrients, suspended solids, and organic enrichment/low dissolved oxygen.

Over the past 14 years, 3,628 miles of river and stream miles along with 17,990 acres of lakes have been removed from the impaired waters list. Although efforts to improve waters have been implemented, the success of these efforts is not readily apparent because there is no formal mechanism for demonstrating such improvements. Only complete recovery, which shows total restoration of the water quality standard, is documented. Matters that are affecting the demonstration of ongoing progress in water resource restoration may include:

1. The significant lag time between removal or reduction of a pollutant source and the corresponding water quality response.

2. Insufficient data collected to verify restoration.

3. No technical procedure is in place for showing improvement that has occurred, but still falls short of meeting standards for delisting.
PURPOSE

The purpose of these guidelines is to explain a process for DEP staff and others involved in water quality monitoring who are interested in documenting and reporting measurable, incremental improvements in water quality in streams, rivers and lakes that result in progress towards an impairment free condition. Improvements can occur through restoration efforts, enhancements, or removal of threats to the integrity of a waterbody.

The information collected through the guidelines will be used to share stories about surface waters that show incremental improvement largely due to the voluntary actions of communities in which the rivers, streams, lakes and ponds are located.

“Improving Waters” is the term applied to waterbodies where their quality has increased in some measurable way. To qualify as “improving water,” clearly definable progress toward an impairment free condition is demonstrated through scientific measurement and documentation. Improvements can occur because of restoration efforts, enhancements, or removal of threats to the health and/or integrity of a waterbody.

Generally, a waterbody that is a lake or stream will be evaluated for improvement if it is either on the federal Clean Water Act Section 303(d) List of Impaired Waters or when the waterbody is at risk of being placed on the 303(d) list. (Pennsylvania’s Section 303(d) list can be found at www.dep.pa.gov, search Water Quality.)

To be considered an improving water, documentation must demonstrate that after restoration efforts, enhancements, or removal of threats to the integrity of a waterbody, the condition(s) within the waterbody have significantly improved over the conditions used to place the waterbody on the 303(d) list or to prevent further degradation.

INCREMENTAL IMPROVEMENT

Incremental improvement will be documented as a measurable, technically defensible, and positive change in the condition of a waterbody or watershed. Established, scientifically sound monitoring, and assessment protocols will be used to demonstrate improvement.

Documenting incremental improvements is beneficial in that it provides recognition for the communities and their efforts to restore and protect water resources.

- **Measurement of incremental improvement** can be accomplished in different ways, provided the measurement method is scientifically sound, appropriately used, and sufficiently sensitive enough to generate data showing a positive change in conditions.

- **Measurable parameters and indicators** of incremental improvement may include biological, chemical, and physical properties or attributes of an aquatic ecosystem that can be used to reliably indicate a positive change in conditions.

- **A positive change in condition** means a measurable improvement that is related to a reduction in a specific pollutant load, a reduction in total number of impairment causes, a reduction in an
accepted non-pollutant measure of degradation, or an increase in an accepted measure of positive waterbody condition relevant to designated use support.

In rivers and streams there must be:

- At least one chemical parameter that shows improvement of 15% or greater over baseline condition OR;
- Benthic macroinvertebrate metric scores showing improvement over baseline as described below OR;
- A combination of an increase in benthic macroinvertebrate metric scores combined with an improvement in visual habitat scores over baseline as described below OR;
- Improvement in a combination of physical parameters as described below.

In lakes, ponds, and reservoirs there must be:

- Improvement trends in Trophic State Indices (TSI) OR;
- A single physical or chemical parameter shows improvement of at least 15% over baseline.

There will be variability in results over time due to natural variability and normal sample error. It must be demonstrated that sample results or scores are the result of increased water quality and habitat and not artifacts of variability. This is most easily accomplished by taking multiple samples over time and space. In most waterbodies, monitoring will need to continue for three years or more. There may be some waterbodies such as those being actively treated for abandoned mine drainage where incremental improvement will be observed in less than three years.

A. Suggested Assessment Methods for Documenting Incremental Improvement

1. DEP Instream Comprehensive Evaluation (ICE) Surveys. [www.dep.pa.gov](http://www.dep.pa.gov), search Water Quality


3. Improving Waters Assessment Methods for Watersheds with Agricultural Impacts. See Appendix 2 of this document.

4. Improving Waters Assessment Methods for Abandoned Mine Drainage Impacts. See Appendix 3 of this document.

5. Improving Waters Assessment Methods for Stormwater Impacts. See Appendix 4 of this document.

B. Data Analysis for Determining Incremental Improvement

1. Assessment of Chemical Parameters

Analysis of chemical parameters alone can be used to define incremental improvement when results show a positive change in conditions. In general, this means that certain parameters previously not meeting standards are moving closer - by 15% or more - to meeting the standards set in Pa. Code Title 25, Chapter 93 Water Quality Standards - Specific Water Quality criteria (Chapter 93 WQS).

www.pacode.com/secure/data/025/chapter93/s93.7.html

2. Assessment of Biological Parameters

a. Benthic Macroinvertebrates

Analysis of the Benthic Macroinvertebrate community alone can be used to define incremental improvement when results show a significant increase in the abundance and diversity of organisms. In general this means that organisms are identified to the lowest feasible taxonomic level and tabulated. The composite data is applied to a set of biological metrics to obtain an Index of Biological Integrity or Water Quality Score.

Historical biological datasets will not necessarily be complete so it is important to collect data that will be comparable to those older datasets. The current DEP methodology is preferred where possible and practical; however, in many cases this level of rigor may not be necessary to show incremental improvement. For example, in a severely degraded stream, historical datasets could show that the stream was devoid of nearly all aquatic macroinvertebrate organisms. In such cases, simply identifying the reestablishment of any macroinvertebrate population is evidence of incremental improvement.

While there is no need to apply any specific taxonomic analysis in extreme cases of impairment, a meaningful level of rigor is required under less extreme circumstances. When working in waterbodies where extreme degradation to the biotic community occurred (e.g., AMD pollution resulting in complete removal of life from a stream) a simple screening of the condition is adequate to show incremental improvement. When working with a less extreme case (e.g., significant, but not total loss of the benthic community resulting from prolonged sediment pollution), macroinvertebrate organisms should be identified to the taxonomic ‘family’ level or lower and the data should be applied to several logical biometrics.

For data comparisons, new data should consist of annual sampling events over at least three years after the installation of BMPs or removal of pollutant source.
The collections should occur at the same time of year for each sampling location between October 1st and May 1st.

If the Biosurvey protocol described in *Pennsylvania Senior Environment Corps Water Quality Field Manual* ([www.natureabounds.org/SEC_Manuals.html](http://www.natureabounds.org/SEC_Manuals.html)) is used, a score based on a scale of zero to 40+ that increases by 6 or more from a previous sampling at the same time of year indicates incremental improvement.

If the more rigorous DEP methodology is used, an Index of Biological Integrity (IBI) score, which is based on a scale of 0 to 100, can be used to document incremental improvement when there is an increase of 15 over the historical data collected at the same time of year.

b. **Fecal Coliform Bacteria**

Decreasing Fecal Coliform Bacteria counts can be used in combination with reductions in other parameters such as nitrogen, phosphorous, and sediment to indicate incremental improvement. In cases where bacteria are a concern, five or more samples are used to obtain a geometric mean. In many cases where bacteria are a problem, the numbers of colonies formed on a test plate (per 100/ml of water) will be much higher than the number suitable for human contact. Therefore, in cases where human contact criteria are not met, and the exceedance is >10X the standard, an indication of incremental improvement will be defined as a reduction in the geometric mean by a factor of 10. (For example, a baseline/historical geometric mean of 33,500 colonies per 100 ml of water dropping below 3,350 colonies per 100 ml of water would signify incremental improvement).

In cases where baseline counts are only 3X - 10X greater than the standard an improvement means reducing the count by 2X the standard. Historical counts that are <3X the standard should be reduced to meet the standard in order to signify an improvement.

For determining incremental improvement many user-friendly products such as EasyGel can be used to estimate bacteria counts in the field.

The results obtained by field kits have recognized limitations, but when consistently applied as part of a long-term monitoring program they can be used for supportive evidence of improvement.

c. **Chlorophyll-a (Lakes)**

Chlorophyll-a (chl-a) analyses, done via laboratory analyses or an appropriate calibrated multi-parameter meter, are used in lakes for Trophic State Indices (TSI) calculations. The parameter is tied to algal production, which can be improved (reduced) by a reduction in available nutrients via BMPs in-lake, or as load reductions from the watershed.
A 15% reduction in average or summer chl-a levels or chl-a TSIs indicate incremental improvement, if the original water quality impairment was caused by productivity due to nutrients. Comparisons should be limited to summer samples when worst-case conditions would be most likely. TSIs below 60 are indicative of normal conditions, although sometimes problems do arise with TSIs of 55+; above 65 indicates hypereutrophic conditions. TSIs between 60 and 65 usually coincide with eutrophic conditions and noticeable algal problems or abundant macrophytes growth. Targeted reductions in TSI or chl-a levels are tied to nutrient reductions and are good markers for improving conditions.

d. **Aquatic Invasive Species**

Aquatic invasive species (AIS) influence and continue to affect state assessments of waterbodies. Perceptions and conclusions regarding the impacts of AIS continue to evolve. Many aquatic invasive species are capable of degradation by changing the natural characteristics of the water, reducing the abundance and diversity of native aquatic life, or impeding human uses of the water. Nationally, a number of AIS have been recorded as the cause of impairment for 303(d) listings. Realizing that the degrading effects of AIS can lead to a violation of state water quality standards and to the identification of waters as impaired under Section 303(d) of the Clean Water Act, it is logical that removing any aquatic invasive species should also be considered to be an incremental improvement to any infested waterbody, and preventing AIS introductions should be a goal for all healthy waters.

Any AIS can cause substantial ecological and economic damage where conditions are favorable for its proliferation. Therefore, any AIS (or more generally any non-native species) can, on a case-by-case basis, be considered as a candidate species for inclusion in the process. In other words, there is no “dirty dozen” type of list of species that serves as a complete compilation of species to which this section applies.

The purposeful or circumstantial elimination of any AIS can be considered an incremental improvement to a waterbody if there is reasonable documentation to suggest that the species imposes threat(s) or potential threat(s) to that waterbody, and the following four additional measures are met. Removal of AIS can be considered as an incremental improvement when:

1) Occurrence of a recognized AIS and its relative abundance in the waterbody has been reported, acknowledged, and verified;

2) There is documentation of the means by which eradication or elimination of the AIS has taken place;

3) The eradication is followed up by appropriate monitoring indicating that the AIS has not been found in the waterbody or stream reach of concern for a minimum of three consecutive years (longer periods of monitoring are recommended in cases where viable seed-banks or other extenuating circumstances that would likely cause a reoccurrence are suspected or
known to exist). Monitoring is to be done to an intensity that allows for the reasonable conclusion that no individual specimen remains living in the waterbody or stream reach of concern;

4) The eradication of the AIS should be linked to other improvements in water quality, use, biological condition, management goal(s), or social or economic benefit. Note: One AIS specimen is considered an infestation and a single occurrence should trigger reporting and rapid response.

e. **Plankton (Lakes)**

If plankton studies have been included in past lake assessments, improvement in plankton dynamics can be shown by changes in types/groups and/or overall densities during critical growing-season periods. Bluegreen algae (cyanobacteria) blooms usually coincide with lake problems, especially during summer. An assessment of incremental improvement would be based on documentation of critical Genera, Class or Order algal types, and densities of those algae. This data would be generated by skilled taxonomic lab identifications and precise methodology for the entire sampling, ID, and density calculation process.

Since plankton populations are very dynamic (with changes in density and species because of changes in temperature, day length, and nutrient availability throughout the growing season), year-to-year, comparisons should be limited to worse-case conditions (i.e., summer, roughly mid-July through mid-September). Multi-year comparisons should show an increase in “good” algae, and a decrease in “bad” algae (i.e., bluegreens). This may be difficult to show given the temporal and year-to-year dynamics of plankton populations, and may not even be feasible, but is included here as a possibility.

f. **Macrophytes (Lakes)**

Macrophyte (in-water submerged, emergent, and floating aquatic plants) coverages are an integral part of assessing a waterbody’s Recreational Use. Although macrophytes are important components of aquatic ecosystems, when overly abundant, can become a nuisance and easily impair boating, fishing, and swimming. Invasive species can reduce the quality of habitat for fish and other aquatic organisms, and can eventually out-compete native plant species. Improvements include: reduction or control of invasive species, reduction of surface or underwater coverage (total species) to below 40% of the lake and/or shoreline, and improvement in access within the waterbody.

Incremental Improvements would rely on density and coverage reductions based on successful implementation of BMPs such as chemical treatments, harvesting, dredging and/or watershed BMPs that target nutrient load reductions to the lake/waterbody. Such improvements can be documented by lake mapping of the past and present coverage of macrophytes; photo-documentation; species density studies and/or aerial photos of coverage changes over time over multiple years. Documentation should be made during the summer months when plant growth is maximized.
3. **Assessment of Physical Parameters**

a. **Water Temperature**

Decreasing water temperatures - lower average high temperature in summer months as compared to historical records can be used in combination with increasing dissolved oxygen to identify incremental improvement in streams. This can be demonstrated on a case-by-case basis, with records over a period of years; for example, as a streamside buffer matures. Before and after graphs of data and data averages can show incremental improvements.

b. **Dissolved Oxygen**

Increasing dissolved oxygen of ≥ 2mg/L can be used in combination with decreasing water temperature to identify incremental improvement in streams - specifically those with buffer BMPs installed.

c. **Erosion and Sedimentation**

A pebble count, performed with each macroinvertebrate survey, can be used in combination with IBI scores to identify incremental improvement in streams. Pebble count histograms can show improvements in pebble/rock size and decreasing sediment-laden streambeds. A shift in the histogram to larger streambed particles/rocks can be related to stream habitat improvement with a comparison of means/minimums and more sizes. [www.dep.pa.gov](http://www.dep.pa.gov), search Water Quality.

d. **Habitat**

1) **Visual Habitat Assessment**

Visual habitat assessment scores can be used in combination with a macroinvertebrate survey to identify improvement in streams. Total habitat score must be equal or greater than the minimum suboptimal habitat score (132 for the rifle/run dominated streams), as well as the minimum suboptimal scores for the instream habitat components of instream cover, epifaunal substrate, embeddedness, and sediment deposition (40 or greater). [www.dep.pa.gov](http://www.dep.pa.gov), search Water Quality.

For data comparisons, new data should consist of a minimum of two sampling events over one year with collections occurring between October 1st and May 1st.

2) **Riparian Forest Buffer Assessment**

Riparian forest buffers have been identified as one of the most effective interventions for controlling non-point source pollution from agricultural, urban, and suburban lands. Buffers also provide mitigation of storm water
runoff, increase wildlife habitat, and cool the water in streams, rivers, and lakes. When conducting a riparian assessment, several elements (age and condition of the buffer, the existence of invasive species, variety of vegetation in the buffer, nearby land use, other land uses in the watershed, deer browsing, field pest, flood plain, ideal buffer size, is it a planted buffer or a natural regeneration, size of the vegetation in the buffer and are there potential hazards) must be considered to conduct a thorough assessment. The art and science of conducting a successful assessment is figuring out how all those elements impact and/or compliment each other in making the riparian buffer as efficient as possible. See DEP’s Riparian Forest Buffer Guidance (DEP Document # 394-5600-001, pages 22-27) for an assessment method with a classification system as detailed below: www.elibrary.dep.state.pa.us/dsweb/Get/Document-82308/394-5600-001.pdf

Class 1

- Width of area with trees and shrubs is 100 feet or greater as measured from top of streambank or lake shoreline
- Minimum 60% uniform canopy cover (area of ground covered by a vertical projection of the canopy of predominantly native shrubs and trees)
- Pennsylvania Noxious Weeds and invasive species are removed and controlled to the extent possible

Class 2

- Width of area with trees and shrubs is 100 feet or greater as measured from top of streambank or lake shoreline
- Less than 60% uniform canopy cover (area of ground covered by a vertical projection of the canopy of predominantly native shrubs and trees)
- Pennsylvania Noxious Weeds and invasive species are removed and controlled to the extent possible

Class 3

- Width of area with trees and shrubs is less than 100 feet as measured from top of streambank or lake shoreline
- Less than 60% uniform canopy cover (area of ground covered by a vertical projection of the canopy of predominantly native shrubs and trees)
- Pennsylvania Noxious Weeds and invasive species present
APPENDICES

Appendix 1. Reporting Template.

Appendix 2. Improving Waters Assessment Methods for Agricultural Impacts.

Appendix 3. Improving Waters Assessment Methods for Abandoned Mine Drainage Impacts.

Appendix 4. Improving Waters Assessment Methods for Stormwater Impacts.
APPENDIX 1

Reporting Template

This template should be used to develop a document that is sent to ep-improvingwaters@pa.gov annually by January 31.

A. Background on waterbody to include: stream/lake name, watershed where waterbody is found (HUC 12 or smaller) county/municipality, number of stream miles and/or lake acres, source/cause of impairment, and summary of historical data.

B. Purpose of monitoring - incremental improvement goals for each parameter.

C. Monitoring Methods to include: protocols used, location (latitude and longitude of sampling locations), frequency of sampling, quality control measures.

D. Description of reasons for improvement. Include as much information as possible (if known) such as BMPs established, funding sources, dates of establishment, responsible groups, etc.

E. Generalized trends in the waterbody to include documentation of sampling results.

F. Recommendations for additional actions to restore and protect waterbody.
APPENDIX 2

Improving Waters Assessment Methods for Agricultural Impacts

Chemical/Physical Indicators:

1. **Grab Sample for Laboratory Analysis: SAC Code - 906**

<table>
<thead>
<tr>
<th>Test Code</th>
<th>Test Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00095</td>
<td>Specific Conductivity @ 25.0 C</td>
</tr>
<tr>
<td>00410</td>
<td>Alkalinity Total as CACO3 (Titrimetric)</td>
</tr>
<tr>
<td>00530</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>00600A</td>
<td>Nitrogen Total as N</td>
</tr>
<tr>
<td>00610A</td>
<td>Ammonia Total as Nitrogen</td>
</tr>
<tr>
<td>00615A</td>
<td>Nitrite Nitrogen, Total Automated</td>
</tr>
<tr>
<td>00620</td>
<td>Nitrate as Nitrogen</td>
</tr>
<tr>
<td>00665A</td>
<td>Phosphorus, Total as P</td>
</tr>
</tbody>
</table>

Required bottle ware and preservatives for SAC 906: (1) 500 ml HDPE unpreserved (general chemistry); (1) 125 ml HDPE preserved with 10% H2SO4 to pH < 2 (N/P)

2. **Field Survey**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water temperature</td>
<td>In field with armored thermometer or meter with thyrister.</td>
</tr>
<tr>
<td>pH</td>
<td>In field with meter.</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Field measurement in a riffle with meter.</td>
</tr>
<tr>
<td>Habitat assessment</td>
<td>Riffle/Run Assessment Protocol - DEP ICE Protocol * Appendix B.</td>
</tr>
<tr>
<td>Photo documentation</td>
<td>At all sampling locations before and after installation of conservation practices.</td>
</tr>
<tr>
<td>TDS/Conductivity</td>
<td>In field with meter.</td>
</tr>
<tr>
<td>Stream Flow</td>
<td>Embody float method or use of flow meter.</td>
</tr>
<tr>
<td>Sedimentation</td>
<td>Pebble Count Procedure - DEP ICE Protocol * Appendix G.</td>
</tr>
</tbody>
</table>

*www.dep.pa.gov*, search Water Quality

Biological Indicators:

1. **Benthic Macroinvertebrates**

Use one of the following:


2. **Bacteria (as needed)**

Bacteriological samples are collected at the discretion of the field investigator if there is a need to assess potable water supply or recreational use impairment. Use DEP ICE Protocol ([www.dep.pa.gov](http://www.dep.pa.gov), search Water Quality).

**Frequency:**

The frequency of monitoring will be quarterly for one year prior to installation of Best Management Practices (BMPs) (if possible) and quarterly for at least five years after installation of BMPs. The exception to the above is that macroinvertebrate monitoring, habitat assessment, and Wolman Pebble Count will be done once between October 1 and May 1 prior to installation of BMPs and once between October 1 and May 1 annually for five years after installation of the BMPs.

**Quality Assurance Measures:**

Meters will be calibrated according to manufacturer’s recommendations. Quality control samples will be taken to ensure valid data are collected. Depending on the parameter, quality control samples will consist of field blanks, standards checks, and duplicate samples or split samples for every 10 samples.

**Data Management and Analysis:**

Chemical and physical data will be stored in an Excel database. A trend analysis will be performed after eight discrete sampling events for chemical/physical indicators following BMP implementation.
APPENDIX 3

Improving Waters Assessment Methods for Abandoned Mine Drainage Impacts

Chemical/Physical Indicators:

1. **Grab Sample for Laboratory Analysis: SAC Code - 909**

<table>
<thead>
<tr>
<th>Test Code</th>
<th>Test Description</th>
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</thead>
<tbody>
<tr>
<td>00403</td>
<td>pH, Lab (Electrometric)</td>
</tr>
<tr>
<td>00410</td>
<td>Alkalinity Total as CACO3 (Titrimetric)</td>
</tr>
<tr>
<td>00530</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>00900</td>
<td>Hardness Total (Calculated)</td>
</tr>
<tr>
<td>00916A</td>
<td>Calcium Total by Trace Elements in Waters &amp; Wastes by ICP</td>
</tr>
<tr>
<td>00927A</td>
<td>Magnesium, Total by Trace Elements in Waters &amp; Wastes by ICP</td>
</tr>
<tr>
<td>00945</td>
<td>Sulfate by Ion Chromatograph</td>
</tr>
<tr>
<td>01045A</td>
<td>Iron, Total by Trace Elements in Waters &amp; Wastes by ICP</td>
</tr>
<tr>
<td>01055A</td>
<td>Manganese, Total by Trace Elements in Waters &amp; Wastes by ICP</td>
</tr>
<tr>
<td>01092H</td>
<td>Zinc, Total by Trace Elements in Waters &amp; Wastes by ICPMS</td>
</tr>
<tr>
<td>01105H</td>
<td>Aluminum, Total by Trace Elements in Waters &amp; Wastes by ICPMS</td>
</tr>
<tr>
<td>70508</td>
<td>Acidity, Total Hot as CACO3 (Titrimetric)</td>
</tr>
</tbody>
</table>

Required bottle ware and preservatives for SAC 909: (1) 500 ml HDPE unpreserved (general chemistry); (1) 125 ml HDPE preserved with 1:1 HNO3 to pH < 2 (metals).

2. **Field Survey**

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water temperature</td>
<td>In field with armored thermometer or meter with thyrister.</td>
</tr>
<tr>
<td>pH</td>
<td>In field with meter.</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Field measurement in a riffle using Winkler Titration or meter.</td>
</tr>
<tr>
<td>Habitat assessment</td>
<td>Rift/Run Assessment Protocol - DEP ICE Protocol * Appendix B.</td>
</tr>
<tr>
<td>Photo documentation</td>
<td>At all sampling locations before and after installation of conservation practices.</td>
</tr>
<tr>
<td>TDS/Conductivity</td>
<td>In field with meter.</td>
</tr>
<tr>
<td>Stream Flow</td>
<td>Embody float method or use of flow meter.</td>
</tr>
<tr>
<td>Sedimentation</td>
<td>Pebble Count Procedure - DEP ICE Protocol * Appendix G.</td>
</tr>
</tbody>
</table>

*www.dep.pa.gov*, search Water Quality

**Biological Indicators:**

1. **Benthic Macroinvertebrates**

Use one of the following:


2. Bacteria (as needed)

Bacteriological samples are collected at the discretion of the field investigator if there is a need to assess potable water supply or recreational use impairment. Use DEP ICE Protocol ([www.dep.pa.gov](http://www.dep.pa.gov), search Water Quality).

**Frequency:**

The frequency of monitoring will be quarterly for one year prior to installation of Best Management Practices (BMPs) (if possible) and quarterly for at least five years after installation of BMPs. The exception to the above is that macroinvertebrate monitoring, habitat assessment, and Wolman Pebble Count will be done once between October 1 and May 1 prior to installation of BMPs and once between October 1 and May 1 annually for five years after installation of the BMPs.

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**Data Management and Analysis:**

Data will be stored in an Excel database. A trend analysis will be performed after 8 discrete sampling events.
APPENDIX 4

Improving Waters Assessment Methods for Stormwater Impacts

Chemical/Physical Indicators:

1. **Grab Sample for Laboratory Analysis: SAC Code - 692**

<table>
<thead>
<tr>
<th>Test Code</th>
<th>Test Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00310</td>
<td>Biochemical Oxygen Demand 5 Day</td>
</tr>
<tr>
<td>00403</td>
<td>pH, Lab (Electrometric)</td>
</tr>
<tr>
<td>00410</td>
<td>Alkalinity Total as CaCO3 (Titrimetric)</td>
</tr>
<tr>
<td>00530</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>00556H</td>
<td>Oil and Grease Method 1664 (Hexane)</td>
</tr>
<tr>
<td>00610A</td>
<td>Ammonia Total as Nitrogen</td>
</tr>
<tr>
<td>00615A</td>
<td>Nitrite Nitrogen, Total, Automated</td>
</tr>
<tr>
<td>00620A</td>
<td>Nitrate as Nitrogen</td>
</tr>
<tr>
<td>00665A</td>
<td>Phosphorus, Total as P</td>
</tr>
<tr>
<td>00900</td>
<td>Hardness Total (Calculated)</td>
</tr>
<tr>
<td>00916A</td>
<td>Calcium, Total by Trace Elements in Waters &amp; Wastes by ICP</td>
</tr>
<tr>
<td>00927A</td>
<td>Magnesium, Total by Trace Elements in Waters &amp; Wastes by ICP</td>
</tr>
<tr>
<td>01027H</td>
<td>Chromium, Total by Trace Elements in Waters &amp; Wastes by ICP</td>
</tr>
<tr>
<td>01034A</td>
<td>Copper, Total by Trace Elements in Waters &amp; Wastes by ICP</td>
</tr>
<tr>
<td>01042A</td>
<td>Iron, Total by Trace Elements in Waters &amp; Wastes by ICP</td>
</tr>
<tr>
<td>01051H</td>
<td>Lead, Total by Trace Elements in Waters &amp; Wastes by ICPMS</td>
</tr>
<tr>
<td>01092H</td>
<td>Zinc, Total by Trace Elements in Waters &amp; Wastes by ICPMS</td>
</tr>
<tr>
<td>01105H</td>
<td>Aluminum, Total by Trace Elements in Waters &amp; Wastes by ICPMS</td>
</tr>
<tr>
<td>70300U</td>
<td>Total Dissolved Solids @ 180 C by USGS-I-1750</td>
</tr>
<tr>
<td>71890I</td>
<td>Mercury, Dissolved</td>
</tr>
</tbody>
</table>

2. **Field Survey**

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water temperature</td>
<td>In field with armored thermometer or meter with thyrister.</td>
</tr>
<tr>
<td>pH</td>
<td>In field with meter.</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Field measurement in a riffle using Winkler Titration or meter.</td>
</tr>
<tr>
<td>Habitat assessment</td>
<td>Rifflle/Run Assessment Protocol - DEP ICE Protocol * Appendix B.</td>
</tr>
<tr>
<td>Photo documentation</td>
<td>At all sampling locations before and after installation of conservation practices.</td>
</tr>
<tr>
<td>TDS/Conductivity</td>
<td>In field with meter.</td>
</tr>
<tr>
<td>Stream Flow</td>
<td>Embody float method or use of flow meter.</td>
</tr>
<tr>
<td>Sedimentation</td>
<td>Pebble Count Procedure - DEP ICE Protocol * Appendix G.</td>
</tr>
</tbody>
</table>

*www.dep.pa.gov*, search Water Quality
Biological Indicators:

1. Benthic Macroinvertebrates

Use one of the following:


2. Bacteria (as needed)

Bacteriological samples are collected at the discretion of the field investigator if there is a need to assess potable water supply or recreational use impairment. Use DEP ICE Protocol ([www.dep.pa.gov](http://www.dep.pa.gov), search Water Quality).

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