Flint, Michigan Sampling Support Project

Drinking Water Lead and Water Quality Sampling
Quality Assurance Project Plan (QAPP)

Conducted by: **U.S. Environmental Protection Agency**
Region 5 Ground Water and Drinking Water Branch
Chicago, Illinois

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List of Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
CCT	Corrosion Control Treatment
CRL	Chicago Regional Laboratory
DBP	Disinfection Byproducts
E. coli	*Escherichia coli*
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
GWDWB	Ground Water and Drinking Water Branch
HAA9	Nine Haloacetic Acids
HDPE	high density polyethylene
H_2SO_4	sulfuric acid
HNO_3	nitric acid
KWA	Karegnondi Water Authority
LDPE	low density polyethylene
LIMS	Laboratory Information Management System
LSL	Lead Service Line
MDEQ	Michigan Department of Environmental Quality
MDHHS	Michigan Department of Health and Human Services
µg/L	micrograms per liter
mL	milliliter
NPDWR	National Primary Drinking Water Regulations
NSF	NSF International
ORD	Office of Research and Development
PVC	polyvinyl chloride
RL	Reporting Limit
SOP	Standard Operating Procedure
SU	Standard Unit
Task Force	Flint Safe Drinking Water Task Force
TDS	total dissolved solids
TTHM	Total Trihalomethanes
QA	Quality Assurance
QAPP	Quality Assurance Project Plan

2. Distribution List

On October 16, 2015, U.S. Environmental Protection Agency (EPA) established the Flint Safe Drinking Water Task Force (Task Force) to provide the Agency's technical expertise through regular dialogue with designated officials from Michigan Department of Environmental Quality and the City of Flint. Key Points of Contact at EPA, City of Flint, and Michigan Department of Environmental Quality (MDEQ) are listed below. In consultation with the Task Force, EPA's Water Division and EPA's Office of Research and Development (ORD) may identify additional contacts for inclusion in this distribution list.

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3. Project Organization

The Task Force is responsible for overseeing the provision of technical assistance to the City of Flint.

The EPA Water Division is responsible for project development, oversight, and implementation in coordination with the Task Force, MDEQ, City of Flint, EPA and contract laboratories, and EPA ORD. This includes oversight of all sampling projects, selection of sampling locations, training for water sampling activities, coordination of sampling containers and return shipment, and preparation of the sampling summary reports and final project reports. The EPA Water Division is also responsible for maintaining the documents listed under Project Officer in Section 14 and any follow-up documentation, as well as distributing copies of the final EPA sampling results to all relevant parties (see Section 2) and posting results on EPA's Flint Drinking Water Response website.

The Chicago Regional Laboratory (CRL) Director is responsible for overseeing the provision of sampling supplies and coordinating laboratory analyses to be performed at CRL and in other EPA regional laboratories. This includes oversight of all EPA CRL quality assurance requirements, including data review and qualification of the data. The CRL Director is also responsible for providing the Laboratory Data Report (analytical results) to the Technical Contacts in the EPA Water Division and maintaining the documents listed under EPA CRL in Section 14.

Other EPA Laboratories and contract laboratories may be identified for support laboratory analytical services. It is currently anticipated that Region 1, Region 4, and Region 10 as well as the PHILIS Contract Laboratory (e.g., TestAmerica Laboratories, Inc.), will provide analytical services under this Quality Assurance Project Plan (QAPP). In addition, Region 7 was involved in the laboratory analytical services prior to March 2016. Each laboratory contract program manager is responsible for overseeing the provision of sampling supplies and coordinating laboratory analyses to be performed in EPA laboratories. Each EPA laboratory director or laboratory contract program manager will be responsible for oversight of the applicable laboratory quality assurance requirements, including data review and qualification of the data. Each EPA laboratory director or laboratory contract program manager is also responsible for providing the Laboratory Data Report (analytical results) to the Technical Contacts in the EPA Water Division and maintaining the documents listed under Other Laboratories in Section 14.

The EPA Water Team Field Leads are responsible for coordinating with and providing technical assistance and training to field sampling coordinators for all sampling activities, including consumable supplies and calibration procedures.

Field sampling coordinators, either EPA personnel or other personnel trained in sampling techniques and under the oversight of EPA, are responsible for field implementation of water sampling activities, including coordination with residents involved in sampling activities, completing applicable sampling activities, conducting field measurements and field preservation, verifying the completeness of field sampling forms and chains-of-custody, and shipping samples for laboratory analysis, as described in this QAPP.

The EPA Water Division Technical Contact(s), in coordination with the Task Force, are responsible for amending the QAPP and sampling instructions, as required based on analytical results and field observations. The EPA Water Division Technical Contact(s) are responsible for assisting with data management, interpreting the sampling results, and evaluating the need for further action.

4. Background

Lead is a toxic metal that can be harmful to human health when ingested. Young children are particularly sensitive to the effects of lead because their bodies are still undergoing development. Lead can be released into drinking water primarily from interaction of the water with plumbing materials containing lead through corrosion, as well as physical plumbing disturbances and changes to water chemistry. Common sources of lead in drinking water include lead service lines (LSL), as well as lead solder, fluxes, other pipes and pipe fittings, fixtures, and sediment within the water distribution network.

Drinking water treatment and distribution systems can be complex, involving many different chemical, physical, and microbial processes that can directly affect water quality. Drinking water rules and regulations are based on contaminant levels found in the source water as well as contaminants that can enter the water distribution system or increase within the distribution system. Monitoring in a public water system is conducted at the source, within the treatment plant, and across the distribution system. Treatment processes must be adjusted based on water quality changes in the source water, which can affect the performance of various treatment processes. Water quality changes in the distribution system can directly impact microbial activity; corrosion of metals such as lead, copper, and iron; formation of disinfection byproducts; taste and odor of the water; and physical appearance of the water. In many cases, water utilities add chemicals to their water, such as corrosion inhibitors and disinfectants, the fate and subsequent effectiveness of which can change in the distribution system. Optimal Corrosion Control Treatment (CCT) is defined as treatment that minimizes lead and copper levels at users' taps while ensuring that the treatment does not cause the water system to violate any National Primary Drinking Water Regulations (NPDWR).

Scales, deposits, and sediment develop on and in all water distribution pipes. These materials may have widely different compositions depending on the type of metal that is corroding, the water chemistry, and the inhibitors that are added to the drinking water. Scales may have detrimental impacts on water distribution systems in numerous ways. For example, scales can provide sinks for toxic metals (e.g., copper and lead), microbes, or aesthetically problematic constituents (e.g., manganese, iron, calcium, and zinc) via sorption, precipitation, or corrosion product growth. These metals or constituents can be released because of subsequent water quality changes or physical/hydraulic disturbances. However, scales in the distribution system can also protect water by reducing the rate of corrosion or metal release in drinking water. Scales also enable reductions in exposure to regulated metals, such as copper and lead.

5. Project Description

The EPA has offered, and the City of Flint has accepted, the assistance of EPA experts on corrosion and corrosion control treatment under current water quality conditions as well as during and after the upcoming transition to the Karegnondi Water Authority (KWA) pipeline. EPA will work, in cooperation with local partners and voluntary residents/owners, to conduct drinking water testing in Flint including faucet filter evaluation, distribution system monitoring for disinfectant and disinfection byproducts (DBP), lead source/release diagnostic evaluation, heath and direct contact exposure evaluation, aerator particulate evaluation, distribution system monitoring for treatment assessment, distribution system sampling for Coliform bacteria, resident-requested sampling and hot water evaluation, special purpose sampling, and lead service line (LSL) extraction and pipe scale evaluation, as discussed in the following sections. Details regarding sampling are provided in Appendices A through H.

5.1 Faucet Filter Evaluation

Water samples will be collected to assess concentrations of lead in filtered and unfiltered drinking water at selected sampling sites, including homes where existing analytical data indicates elevated lead in water concentrations above 150 micrograms per liter (µg/L). In general, three grab water samples will be collected at the kitchen faucet at each selected sampling site, as discussed below.

- Filtered Water, Existing Faucet Filter - One grab sample will be collected through the existing water filter (if present). The field sampling coordinators will note the type (brand) of the filter, status of the filter indicator, and available information from the resident regarding the time since the filter or cartridge was installed.
- Unfiltered Water - The filter will be removed, and an unfiltered water sample will be collected as the first grab sample following removal of the filter and/or aerator. No cleaning or flushing will be conducted prior to the unfiltered water grab sampling.
- Filtered Water, New Faucet Filter - Following the collection of the unfiltered sample, a new filter or new filter cartridge will be installed, and the water will be allowed to run through the new filter for approximately two minutes. Following installation and flushing of the new filter or replacement filter cartridge, a grab sample will be collected through the newly installed filter.

If no faucet filter is currently in place at the location, or if a faucet filter is unable to be installed, the field sampling coordinators will collect fewer samples and will document reasoning in the field notes. Samples will be collected in accordance with Section 8.1 and analyzed for total metals in accordance with Section 9.1. Specific procedures for faucet filter evaluation sampling are provided in Appendix A. Water samples will be sent to EPA or contract laboratories for analysis of total metals including lead.

Beginning in late March 2016, a modified procedure was implemented to include the collection of unfiltered samples following a minimum of 6 hours stagnation. When stagnation can be confirmed, two water samples will be collected as described below at each selected sampling site, generally at the kitchen faucet.

- Unfiltered Water - The filter will be removed (or bypassed), and an unfiltered water sample will be collected as a first flush sample following removal of the filter and/or aerator and a minimum of 6 hours stagnation. No cleaning or flushing will be conducted prior to the unfiltered water grab sampling.
- Filtered Water, Existing (or New) Faucet Filter - One grab sample will be collected through the existing water filter (if present). If no existing filter is present, field sampling coordinators will install and flush a new filter, as described above, then collect the filtered water sample through the newly-installed water filter. The field sampling coordinators will note the type (brand) of the filter, status of the filter indicator, and available information from the resident regarding the time since the filter or cartridge was installed.

The results of the filtered and unfiltered grab samples will be evaluated to assess whether the NSF International (NSF)-certified household filters being distributed are effective for removal of lead above the NSF-designated criteria of 150 μg/L. The total number of sampling sites for this task will be determined based on evaluation of available data and field conditions.

5.2 Distribution System Monitoring for Disinfectant and Disinfectant Byproducts

Chlorine, pH, and temperature will be measured weekly or biweekly at up to 35 representative sites in the distribution system in accordance with the sampling plan developed by ORD (see Appendix B).

Total trihalomethanes (TTHM) and nine haloacetic acids (HAA9) will be measured biweekly or monthly at up to 35 sites within the distribution system in accordance with the sampling plan developed by ORD (see Appendix B).

Samples will be collected in accordance with Section 8.1 and analyzed for TTHMs and HAA9 in accordance with Section 9.1. Specific procedures for distribution system water quality monitoring for disinfectant and DBPs are provided in Appendix B. Field water quality parameters, including pH, temperature, and chlorine residual, will be measured and recorded in the field. All TTHM and HAA9 samples will be collected into certified clean, pre-preserved vials provided by the PHILIS Contract Laboratory, and field sampling coordinators will ensure all vials are collected with zero headspace. The TTHM and HAA9 samples will be sent to and analyzed by the PHILIS Contract Laboratory.

Distribution system water quality monitoring results will be used evaluate DBP formation and potential microbial contamination, including chlorine residual, TTHM, and HAA9 levels. The number and location of sites and the frequency of sampling may be adjusted based on the previous round(s) of sampling.

5.3 Lead Source/Release Diagnostic Evaluation

Sequential sampling was conducted in January through March 2016 at more than 100 'candidate' sampling sites selected based on available information including previous high lead concentration results, indicating the potential presence of LSLs. The results of the initial

sampling from the candidate sampling sites, along with available plumbing information, has been used to identify and select approximately 45 single-family residences with a variety of plumbing materials, including sites which may have LSLs and sites which may not have LSLs, for evaluating differences in lead release from different potential sources of lead. Additional sequential sampling, plumbing investigations, and other work may be conducted to focus on specific issues, such as homes which likely do not have LSLs with results indicating have high lead sources potentially within the home plumbing.

Beginning in May 2016, the selected single-family residences with LSLs or significant interior sources of lead will be sampled approximately every two months for subsequent evaluation of corrosion control treatment and effectiveness. Procedures for subsequent rounds of sequential sampling may be tailored for each single-family residence, based on available information including analytical results and plumbing information. In addition, smaller bottle sizes (e.g., 500-mL) may be used to further evaluate potential sources of lead in interior plumbing.

Following at least 6 hours of stagnation, sequential samples will be collected in accordance with Section 8.1 and analyzed for total metals in accordance with Section 9.1. Specific procedures for lead source/release diagnostic evaluation sampling are provided in Appendix C. Water samples will be sent to EPA laboratories for analysis of total metals including lead. Tin will be added to the list of parameters to be analyzed starting with second round of sequential sampling in May 2016.

Lead source/release diagnostic evaluation sampling results will be evaluated by the Task Force so that any necessary corrosion control adjustments can be implemented. The total number of sampling events for this task will be determined based on evaluation of available data.

5.4 Health and Direct Contact Exposure Evaluation

Water samples will be collected to assess concentrations of potential health concerns including direct contact exposure from identified potential irritants that may be present in drinking water. EPA will coordinate with Michigan Department of Health and Human Services (MDHHS) and Agency for Toxic Substances and Disease Registry (ATSDR) to collect grab water samples from bathroom faucet(s), bathtub tap(s), shower head(s), and kitchen faucets at homes selected by MDHHS and ATSDR. The results of the grab water samples will be provided to MDHHS and ATSDR for evaluation of any health concerns or source(s) of skin irritants present in drinking water that is used for washing and bathing. The request letter from MDHHS is included in Appendix D; MDHHS subsequently clarified that mercury analysis is not needed.

Grab water samples will be analyzed for potential skin irritants and water quality parameters identified by MDHHS and ATSDR, including laboratory analysis for total metals (long list), total dissolved solids (TDS), alkalinity, sulfate, chloride, fluoride, and hardness and field measurement including pH, chlorine residual, turbidity, and conductivity. The following samples will be collected at each location at the discretion of the field sampling coordinators:

- Kitchen sink faucet – one set of cold water samples analyzed for total metals and water quality parameters including TDS, alkalinity, sulfate, chloride, fluoride, hardness, pH, chlorine residual, turbidity, and conductivity

- Bathroom sink faucet – one cold water sample analyzed for total metals
- Bathtub faucet – one cold water sample analyzed for total metals
- Shower faucet – one cold water sample analyzed for total metals
- Bathtub or Shower faucet (whichever is used more) – one set of hot water samples analyzed for total metals and water quality parameters including TDS, alkalinity, sulfate, chloride, fluoride, and hardness, pH, chlorine residual, turbidity, and conductivity

At the direction of MDHHS and ATSDR, turbidity, conductivity, and total dissolved solids were discontinued at the end of March 2016.

Specific procedures for sampling for health and direct contact exposure evaluation are provided in Appendix D-1. Grab samples should generally be collected after removing any aerator or faucet filter and bypassing existing whole house filter(s) and/or water softeners. If a faucet filter is currently in use at the sampling site, field sampling coordinators may collect additional filtered water sample(s) and document the sample collection methods in the field records. Field sampling coordinators will also record additional field observations including the presence and descriptions of any color, odor, and sediment or debris in the water from each tap sampled.

At the request of MDHHS and ATSDR, additional evaluation is being conducted in April 2016 at a limited number of homes (e.g., 5 homes with reported health issues and 5 "control" homes without health concerns). Water samples will be evaluated for an extended list of organic compounds including volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), and disinfection byproducts (DBP) to compare water quality at homes with reported health concerns in comparison to homes without health concerns. Cold water samples will be collected from bathtub faucets, following a minimum of 6 hours stagnation, and then hot water samples will be collected after running the hot water at the bathtub's maximum setting for approximately one minute. Specific procedures for sampling for the limited "pilot" evaluation are provided in Appendix D-2.

Samples will be collected and analyzed in accordance with Sections 8.1 and Section 9.1, respectively. Specific procedures for sampling for health and direct contact exposure evaluation are provided in Appendices D-1 and D-2. Field water quality parameters, including pH, turbidity, conductivity, and chlorine residual, will be measured and recorded in the field, and water samples will be sent to EPA or contract laboratories for analysis of the remaining parameters.

5.5 Aerator Particulate Evaluation

During scheduled sampling events at selected locations with previously reported high lead results, field sampling coordinators may collect scale and debris that has accumulated on aerators and water filter screens. Solids samples will be collected at the discretion of field sampling coordinators and only if sufficient solid material is present behind the aerator and/or water filter screen at a given sampling location. Photographs will be taken onsite of the scale/debris on the aerators and screens, and field observations will be recorded. Aerator particulate sampling will generally be conducted while at a sampling site for other sampling activities under this QAPP.

Samples will be collected in accordance with Section 8.1 and analyzed for total metals in accordance with Section 9.1. Specific procedures for aerator particulate evaluation sampling are

provided in Appendix E. Solid samples will be sent to the PHILIS Contract Laboratory for analysis of total metals including lead.

Aerator particulate analytical results will be evaluated and used to produce educational material to reinforce the need for residents to periodically clean their aerators. The total number of sampling locations for this task will be determined based on evaluation of available data. This sampling effort will continue until sufficient information has been obtained to produce educational material.

5.6 Distribution System Monitoring for Treatment Assessment

Information regarding the water quality in the distribution system will be collected to evaluate the stability of the water quality throughout the distribution system, and to detect locations that may have the highest risk of lead release or the presence of microbial contamination.

Distribution system water quality assessment sampling may be conducted at sampling sites after the completion of other sampling activities as specified below.

- Field water quality parameters, including pH and chlorine residual, will be measured following grab sampling, including sampling faucet filter evaluation (Section 5.1), health and direct contact exposure evaluation (Section 5.4), and resident-requested sampling (Section 5.8) and following sequential sampling for lead source/release diagnostic evaluation (Section 5.3).
- Water samples for water quality parameters including total phosphorous, alkalinity, chloride, sulfate, and fluoride will be collected following sequential sampling for lead source/release diagnostic evaluation (Section 5.3).

Distribution system water quality sampling will be conducted following at least 5 minutes of flushing, depending on the size and length of plumbing between the sampling location and the water distribution main. Field water quality parameters, including pH and chlorine residual, will be measured and recorded in the field, and water samples will be sent to EPA CRL for laboratory analysis of the remaining water quality parameters. Samples will be collected and analyzed in accordance with Section 8.1 and Section 9.1, respectively. Specific procedures for distribution system water quality monitoring for treatment assessment are provided in Appendix F.

Distribution system water quality characterization assessment results will be used to evaluate:

- corrosion control, including range of pH, alkalinity, total phosphorus, and anions (sulfate, chloride, fluoride) and
- potential for microbial contamination, including chlorine residual.

Data collected on water quality parameters that affect corrosion control can be used along with metals data for lead and copper to set "optimal water quality control parameters", as required by 141.82(f). The total number of sampling sites for this task will be determined based on evaluation of available data and field conditions.

5.7 Distribution System Sampling for Coliform Bacteria

Samples may be collected to assess the presence of Coliform bacteria in drinking water at locations where field monitoring conducted under this QAPP (see Section 5.2 and Section 5.6) indicates low chlorine residual.

EPA will coordinate with Genesee County Health Department or MDHHS to obtain sterile sampling containers, conduct this sampling, and analyze the samples for bacterial indicators including Total Coliform and *Escherichia coli* (abbreviated as *E. coli*). Samples will be couriered to a partner laboratory such as Genesee County Health Department or MDHHS to analyze these samples using Colilert analytical methods. Specific procedures for sampling for Coliform bacteria are provided in Appendix G.

5.8 Resident-Requested Sampling and Hot Water Evaluation

Water samples may be collected at selected sampling sites at the request of residents. In general, two grab water samples will be collected at the kitchen faucet at each selected sampling site, as discussed below.

- Unfiltered Cold Water – After at least 6 hours of stagnation, an unfiltered first-draw cold water sample will be collected. Any faucet filter or aerator will be removed prior to sampling, and any whole house water treatment will be bypassed.
- Unfiltered Hot Water – After the cold water sample is collected, the hot water tap will run until the water is hot and then an unfiltered hot water sample will be collected.

While on-site, the field sampling coordinators will collect information regarding the hot water tank and the resident's willingness to participate in hot water evaluation sampling from their water tank. At selected locations, field sampling coordinators may return to collect hot water samples from the hot water tank drain, to assess the lead levels in hot water tanks.

Samples will be collected in accordance with Section 8.1 and analyzed in accordance with Section 9.1. Specific procedures for resident-requested sampling and hot water evaluation sampling are provided in Appendix H. Water samples will be sent to EPA laboratories for analysis of total metals, including lead.

Hot water sampling results will be evaluated and used to produce educational material to reinforce the need for residents not to use hot water for human consumption (e.g., making baby formula and cooking). The total number of sampling locations for this task will be determined based on evaluation of available data. This sampling effort will continue until sufficient information has been obtained to produce educational material.

5.9 Special Purpose Sampling

At the discretion of the field sampling team, additional field measurements for chlorine, and possibly sampling for Total Coliform and *E. coli,* will be conducted, based on requests from the community regarding concerns over the water quality in their area. Depending on the nature of

the request, sampling may target water within the premise plumbing or water representative of that delivered by the water utility (water main sampling).

The difference between premise plumbing and water main sampling is flushing time. If flushing is conducted for water main sampling, times will be adjusted based on site-specific characteristics (i.e., service line pipe diameter, distance from sample tap to the water main, tap flowrate, etc.) to ensure that measurement captures water from within the water main. The field sampling team will note whether or not flushing occurred, how long, and if determined, the approximate distances and pipe sizes as well as other pertinent information used to determine the flushing time(s) for the samples. Sample results will be marked as Special Purpose (SP) samples so that the measurements are not combined with regularly scheduled or planned distribution system monitoring.

5.10 Lead Service Line Extraction and Pipe Scale Evaluation

In order to inform corrosion control treatment optimization decisions, segments from four LSLs will be extracted and used for assessing the current condition and composition of the scales within the LSLs. Pipe scale analyses on segments of these pipes will be used to determine the type of scales that have formed inside the lead lines under different chlorine levels and water quality conditions.

Four full LSLs will be identified by ORD and the Task Force for initial extraction, including two sites in low chlorine areas and two sites in high chlorine areas. Two 4-foot segments from each LSL will be carefully extracted, packed and shipped to ORD for scale analyses. If possible, the extracted segments should be driven back to ORD to avoid physical disturbances during shipping. Depending on the suitability and condition of the extracted LSLs, additional LSLs may need to extracted using the procedures outlined in this section. Specific procedures for LSL extraction and pipe scale evaluation, including a copy of the ORD Pipe Scale Analysis and Evaluation: Quality Management Plan for Research at the Advanced Photon Source of the Argonne National Laboratory, are provided in Appendix I.

Sequential sampling may be conducted at selected LSL extraction locations, both prior to and following LSL extraction, for evaluation of the effects of LSL removal on drinking water quality. Sequential sampling procedures are provided in Appendix C.

6. Quality Objectives

6.1 Precision

EPA and contract laboratories will perform replicate analysis of known samples to assess method precision. The acceptance criterion for replicate analysis is a maximum of 20 percent (%) Relative Percent Difference, unless otherwise specified by EPA or contract laboratory standard operating procedures (SOP).

6.2 Bias

EPA and contract laboratories will perform analysis of Laboratory Fortified Blanks to assess accuracy/bias. The acceptance criterion for accuracy for the results is to be within plus or minus 10% recovery of the known value, unless otherwise specified by EPA or contract laboratory SOPs.

6.3 Representativeness

The selection of sample locations, analyses, and sample sizes is designed to identify potential sources of lead throughout the plumbing network at each sampling site, and to collect samples that are representative of concentrations of lead and other water quality parameters in City of Flint drinking water.

6.4 Comparability

The analytical methodology for this project is standard analytical methodology used to assess concentrations of lead and other water quality parameters, as described in Section 9.1, in City of Flint drinking water.

Sampling results for sampling activities in this QAPP (see Section 5) are intended to identify appropriate sampling sites, characterize the water quality throughout the distribution system, assess potential risk associated with various water quality and plumbing materials, and to monitor the effectiveness of corrosion control treatment. The sampling results for these sampling activities are not intended to be used to assess compliance with the lead and copper action levels in EPA's Lead and Copper Rule.

6.5 Completeness

Samples will be collected from specified sampling locations, with the goal that one hundred percent (100%) of samples will be analyzed and reported. However, some samples may not generate valid data, and additional sampling may be conducted as needed to meet overall objectives.

6.6 Sensitivity

EPA and contract laboratory reporting limits (RL) for the determination of metals and water quality parameters (see Section 9.1 and Appendix J) meet the objectives of this project.

7. Non-Direct Measurement (Secondary Data)

There are no non-direct measurements associated with this project. However, secondary data previously collected and reported may be used to identify sampling sites.

8. Field Monitoring Requirements

This section includes general procedures for water sampling methods, field water quality testing, and field quality control. Details regarding sampling and field water quality testing are described in Appendices A through H.

8.1 Water Sampling Methods

The following equipment and supplies will be needed to perform field sampling activities:

- HDPE or LDPE pre-certified clean wide-mouth 125-milliliter (mL), 500-mL, and 1,000-mL single use rigid plastic bottles for all metals analysis (preserved to pH<2 with nitric acid HNO_3),
- Pre-certified clean single use sampling containers for other laboratory analyses as determined and provided by EPA CRL or the contract laboratory (method-specific)
    - 125-mL HDPE or LDPE bottles for analysis of total phosphorus (field preserved to pH<2 with sulfuric acid H_2SO_4)
    - 125-mL HDPE or LDPE bottles for analysis of alkalinity and anions (chloride, sulfate, and fluoride)
    - 125-mL HDPE or LDPE bottles for analysis of TDS
    - 40-mL glass VOA vials pre-preserved with sodium thiosulfate for analysis of TTHMs (three vials per sample)
    - 250-mL amber glass bottles pre-preserved with ammonium chloride for analysis of HAA9
    - 40-mL glass VOA vials, Teflon-capped, ascorbic acid pre-dosed for analysis of VOCs including THMs (three vials per sample, field-preserved with hydrochloric acid and zero headspace)
    - 60-mL glass vials, Teflon-capped, ammonium chloride and phosphate buffer pre-dosed for analysis of DBPs General List (three vials per sample, field-preserved with zero headspace)
    - 60-mL glass vials, Teflon-capped, sodium sulfite and phosphate buffer pre-dosed for analysis of Chloral Hydrate (two vials per sample, field-preserved with zero headspace)
    - 1000-mL amber glass bottles, sodium sulfite crystals pre-dosed for analysis of SVOCs (two per sample)
    - Trip blanks for analysis of TTHMs and VOCs
- pH meter including calibration solutions and maintenance equipment,
- Conductivity meter including calibration solutions and maintenance equipment,
- Turbidimeter including calibration solutions and maintenance equipment,
- Thermometer,
- Colorimetric kits for chlorine residual measurement,
- Weatherproof labels,
- Chain-of-custody forms (see Appendix J),
- Sturdy coolers and packing materials (e.g., absorbent material, bubble wrap, trash bags, zip-type plastic bags, shipping tape, and shipping labels),
- Bound field logbook or electronic field note recorder (e.g., iPad with iForms software),

- Photograph labels (e.g., dry erasable board or sheet of paper),
- Global Positioning System (GPS) hand-held locator (optional),
- Indelible ink pen/marker, and
- Camera.

Field sampling coordinators, either EPA personnel or other personnel trained in sampling techniques and under the oversight of EPA, will conduct sampling as summarized below. The field sampling coordinators will prepare field records, chains-of-custody, and sampling labels, conduct any field measurements or field preservation, and ask the residents to verify any stagnation or pre-flushing procedures were followed.

- Each water sample is to be collected from the sample tap outlet directly into the sampling container provided by the laboratory.
- The sampler will follow the protocols provided in Appendices A through H, ensuring that samples are collected in accordance with sampling instructions and training.
- If allowed by the resident, a label with the sample ID written in indelible marker may be placed on the underside of the sampling fixture, in the event the local partner has to re-visit the sampling site. If possible, a photograph may be taken of the sampling fixture (i.e., kitchen faucet); the unique sample ID, date, and sampler should be written on a dry-erase board or sheet of paper and placed in the view for identification of any photograph(s).
- A chain-of-custody form will be filled out to include all samples to be shipped together (i.e., one form per cooler), including sample times and unique sample IDs (nomenclature as described in Appendices A through H).
- Samples will be packaged and shipped overnight or couriered to the applicable EPA or contract laboratory. Whenever possible, overnight shipment will be on the same day as sampling is completed.

Field sampling coordinators will preserve metals samples with nitric acid (HNO_3) to a pH of 2 standard units (SU) or less in the field, prior to shipment to the EPA laboratory. EPA or contract laboratories will check and add additional HNO_3, if needed, within 48 hours of sample receipt. The analytical method allows samples to be preserved within 14 days from sample collection.

Field sampling coordinators will preserve all total phosphate samples with sulfuric acid (H_2SO_4) to a pH below 2 SU immediately after sample collection (i.e., within approximately 15 minutes). Sulfuric acid, nitric acid (if applicable), and narrow-range pH paper will be provided by EPA CRL.

Additional details on specific sampling methods are provided in Appendices A through H. A summary of sampling activities is provided in the table below.

Sample Objective	Sample ID Type	Laboratory Analyses and Approximate Number of Samples per Site Visit											Field Analyses			
		Total Metals (standard list -see note 1)	Total Metals (full list - see note 2)	Total Phosphorus	Total Alkalinity	Anions (see note 3)	TTHMs	HAA9	TDS	Hardness	Total Coliform / E. coli	Chlorine Residual	pH	Temperature	Turbidity	Conductivity
Faucet Filter Evaluation	"FG--", "FGW--", "FGC" and "FH--"	**2 to 3**	NA	NA	NA	NA	NA	NA	NA	NA	**up to 1***	**1***	**1***	NA	NA	NA
Distribution System Monitoring for Disinfectant and DBPs	"T--" and "H--"	NA	NA	NA	NA	NA	**1**	**1**	NA	NA	**up to 1***	**1**	**1**	**1**	NA	NA
Lead Source/Release Diagnostic Evaluation	"S--" and "DS--"	**12 to 30**	NA	**1**	**1**	**1**	NA	NA	NA	NA	**up to 1***	**1***	**1***	NA	NA	NA
Health and Direct Contact Exposure Evaluation	"R--"	NA	**3 to 6**	NA	**1**	**1**	NA	NA	**1 ****	**1**	**up to 1***	**1**	**1**	NA	**1 ****	**1 ****
Aerator Particulate Evaluation	"--AP"	**1**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Distribution System Monitoring for Treatment Assessment	Field and "DS--"	NA	NA	**1**	**1**	**1**	NA	NA	NA	NA	**up to 1***	**1**	**1**	NA	NA	NA
Distribution System Sampling for Coliform Bacteria	Address	NA	NA	NA	NA	NA	NA	NA	NA	NA	**1**	NA	NA	NA	NA	NA
Resident-Requested Sampling and Hot Water Evaluation	"G--"	**2 to 3**	NA	NA	NA	NA	NA	NA	NA	NA	**up to 1***	**1***	**1***	NA	NA	NA
Special Purpose Sampling	TBD															

Notes:

* Field measurements for chlorine residual and pH will generally be collected at each sampling location following other sampling objectives and additional flushing, as needed. Samples for Coliform bacteria may be collected if low chlorine residual is observed in distribution system (fully flushed) samples collected at individual sites.

** At the direction of MDHHS and ATSDR, turbidity, conductivity, and total dissolved solids were discontinued at the end of March 2016.

1. "Standard list" for total metals includes Lead, Copper, Zinc, Aluminum, Iron, Calcium, Cadmium, Potassium, Magnesium, Manganese, Sodium, Nickel, Chromium, and Tin.
2. "Full list" for total metals includes Lead, Copper, Zinc, Aluminum, Iron, Calcium, Cadmium, Potassium, Magnesium, Manganese, Sodium, Nickel, Chromium, and Tin, as well as Antimony, Arsenic, Barium, Beryllium, Boron, Molybdenum, Selenium, Silver, Thallium, and Vanadium.
3. Anions include chloride, fluoride, and sulfate (as SO_4).

8.2 Field Water Quality Testing

Field instruments such as pH meters, conductivity meters, turbidimeters, and colorimetric testing kits (e.g., chlorine residual) will be inspected, maintained, and calibrated according to manufacturer recommendations. Field sampling coordinators will record all field water quality measurements, along with maintenance calibration records, in the field records.

8.3 Field Quality Control

Field blanks will not be collected for this project.

Field replicates will be analyzed at a frequency of approximately 20% (one replicate per 5 samples) for field measurements such as colorimetric analysis (e.g., chlorine residual), turbidimeter, conductivity meter, and pH meter.

Field replicates will be collected and analyzed at a frequency of approximately 5% (one replicate per 20 samples) for TTHM and HAA9 analyses (see Section 5.2). Because metals analytical results in drinking water are highly dependent on the plumbing materials, as well as sequence and volumes of sampling, field replicates will not be collected for metals analysis.

Trip blanks containing analyte-free water will be provided by the PHILIS Contract Laboratory prior to sampling for TTHM and VOC analysis (see Section 5.2 and Section 5.4). Trip blanks will be kept in the cooler(s) and will not be opened in the field. Trip blank analytical results will be used to assess potential contamination sources during sample transportation.

9. Analytical Requirements

9.1 Analytical Methods

Water samples submitted to the appropriate EPA or contract laboratory shall be analyzed in accordance with analytical methods, detection limits, and reporting limits listed below.

Analyte	Analytical Method	Sample Matrix	MDL[1]	Reporting Limit	Hold Time	Bottle Type	Preservative
Total Lead	Based on EPA 200.7/ 200.8	Drinking Water	0.014 µg/L	0.5 µg/L	6 months	HDPE – 125mL or 1,000-mL	HNO_3 to pH<2
Total Metals - Copper, Zinc, Aluminum, Iron, Calcium, Cadmium, Potassium, Magnesium, Manganese, Sodium, Nickel, Chromium, Tin	Based on EPA 200.7/ 200.8	Drinking Water	In accordance with EPA or contract laboratory SOPs.				
Additional Total Metals - Antimony, Arsenic, Barium, Beryllium, Boron, Molybdenum, Selenium, Silver, Thallium, Vanadium	Based on EPA 200.7/ 200.8	Drinking Water	In accordance with EPA or contract laboratory SOPs.				

Analyte	Analytical Method	Sample Matrix	MDL[1] / Reporting Limit	Hold Time	Bottle Type	Preservative
Total Phosphorus	Based on EPA 365.4	Drinking Water	In accordance with EPA CRL SOPs.	28 days	HDPE – 125mL	H_2SO_4 to pH<2, Cool <6C
Total Alkalinity	Based on EPA 310.1	Drinking Water	In accordance with EPA or contract laboratory SOPs.	14 days	HDPE – 125mL	Cool <6C
Water Quality Anions – Sulfate, Chloride, and Fluoride	Based on EPA 300.0	Drinking Water	In accordance with EPA or contract laboratory SOPs.	28 days		Cool <6C
VOCs including TTHMs	EPA 524.2	Drinking Water	In accordance with contract laboratory SOPs.	14 days	Three 40-mL VOAs	Cool <4C, Sodium Thiosulfate or Ascorbic Acid, no headspace
HAA9	EPA 552.3	Drinking Water	In accordance with contract laboratory SOPs.	14 days (21 days for extract)	One 250-mL amber glass	Cool <10C, Ammonium Chloride
TDS	Based on Standard Method 2540C	Drinking Water	In accordance with EPA CRL or contract laboratory SOPs.	7 days	HDPE – 125-mL	Cool <6C
Hardness, Calculated	Based on Standard Method 2340B	Drinking Water	In accordance with EPA CRL SOPs.	6 months	N/A – metals bottle(s)	HNO_3 to pH<2
DBPs General List[3]	EPA 551.1	Drinking Water	In accordance with contract laboratory SOPs.	14 days	Three 60-mL vials	Cool <4C, ammonium chloride and phosphate buffer, no headspace
Chloral Hydrate[3]	EPA 551.1	Drinking Water	In accordance with contract laboratory SOPs.	14 days	Two 60-mL vials	Cool <4C, sodium sulfite and phosphate buffer, no headspace
SVOCs[3]	EPA 525.2	Drinking Water	In accordance with contract laboratory SOPs.	14 days	Two 1,000-mL amber glass	Cool <4C, sodium sulfite

[1] Method Detection Limits - These MDLs will be re-determined before the samples are analyzed per the EPA or contract laboratory's Quality Management Plan which requires MDL studies to be performed yearly.

[2] Method Detection Limits and Reporting Limits for CRL, Region 4, Region 7, Region 10, and PHILIS Contract Laboratory TestAmerica are included in Appendix J-4.

[3] Analytical methods, analyte lists, and detection limits were selected by MDHHS and ATSDR.

Water samples for metals analysis will be digested in accordance with EPA or contract laboratory SOPs. Water samples for other analyses will be prepared in accordance with EPA or contract laboratory SOPs.

9.2 Analytical Quality Control

EPA and contract laboratories have established protocols for the analysis of Quality Control samples with each analytical batch of samples, generally defined as a maximum of twenty samples. Laboratory blank and laboratory fortified blank pairs will be run at a frequency of 1 pair per 20 samples, unless otherwise specified by EPA or contract laboratory SOPs. Laboratory fortified sample and duplicate sample pairs will also be run at a frequency of 1 pair per 10 samples unless otherwise specified by EPA or contract laboratory SOPs. All Quality Control results must be assessed and evaluated on an on-going basis and Quality Control acceptance criteria must be used to determine the validity of the data.

Laboratory blanks run with the samples will not have any detections of lead above the reporting limit, and laboratory fortified blanks and laboratory fortified samples will have recovery limits specified in EPA or contract laboratory SOPs.

Specific information regarding the frequency, composition, acceptance criteria and corrective actions is documented in the specific SOP for a target analyte or procedure, in accordance with applicable EPA or contract laboratory SOPs.

10. Sample Handling and Custody Requirements

10.1 Sample Custody

Distribution and return transportation for water samples analyzed by the laboratory are discussed below.

- EPA CRL or contract laboratories, in coordination with the EPA Water Division, will distribute the sampling bottles and supplies to field sampling coordinators.
- Field sampling coordinators will coordinate sampling schedules with volunteer residents or owners and will provide instructions for any preparation (stagnation or pre-flushing) required prior to collecting water samples.
- Upon arrival at a sampling site, field sampling coordinators will document field observations and resident information including plumbing, physical disturbances, stagnation time, and home water treatment (e.g., whole house filtration, faucet filters, water softener).
- Field sampling coordinators will collect the water samples and complete field sampling records (hard copy field forms or electronic field forms such as iForms software).
- Field sampling coordinators will conduct any field measurements or field preservation.
- Field sampling coordinators will prepare and review sampling labels and chains of custody, including documenting sample time for each sample.
- Field sampling coordinators will ship the water samples overnight to the applicable EPA or contract laboratory, using coolers and shipping labels provided by EPA or the contract

laboratory. Whenever possible, overnight shipment will be on the same day as sampling is completed. Field sampling forms and chain-of-custody forms will be placed in sealed Ziploc bags inside each cooler. A hand-written or typed chain-of-custody form (see Appendix J-1) will be used for this project, and standard EPA chain-of-custody procedures will be followed.

- Shipments will be tracked and accounted for between the field staging area and the laboratories. In general, this will include pre-shipment notification to the applicable laboratory's sample coordinator.
- The laboratory will provide copies of the chains of custody forms following receipt and log-in, and notify the EPA Water Division Technical Contacts and field sampling coordinators regarding any issues noted upon receipt.
- The applicable EPA or contract laboratory will analyze the samples and provide the results to the EPA Water Division.

10.2 Sample Archive/Disposal

The samples received the applicable EPA or contract laboratories, including any digestates, will be archived unless a written request for disposal is provided by EPA Water Division to the applicable EPA or contract laboratory.

11. Instrument/Equipment Testing, Inspection, Maintenance, & Calibration Requirements

11.1 Instrument/Equipment Testing, Inspection, and Maintenance

All laboratory instrumentation will be inspected and maintained according to EPA or contract laboratory maintenance protocols.

Field instruments such as pH meters, turbidimeters, conductivity meters, and colorimetric testing kits will be inspected and maintained by field personnel according to manufacturer recommendations.

11.2 Instrument/Equipment Calibration and Frequency

All laboratory instrumentation will be calibrated according to EPA or contract laboratory SOPs.

Field instruments, such as pH meters, turbidimeters, and conductivity meters will be calibrated according to manufacturer recommendations.

11.3 Inspection/Acceptance of Supplies and Consumables

Sample containers provided by EPA CRL or contract laboratories will be single use and obtained as certified clean from the supplier.

Laboratory reagents are evaluated through the use of laboratory blanks and spikes for purity.

12. Data Management

A diagram presenting data management workflow is presented below.

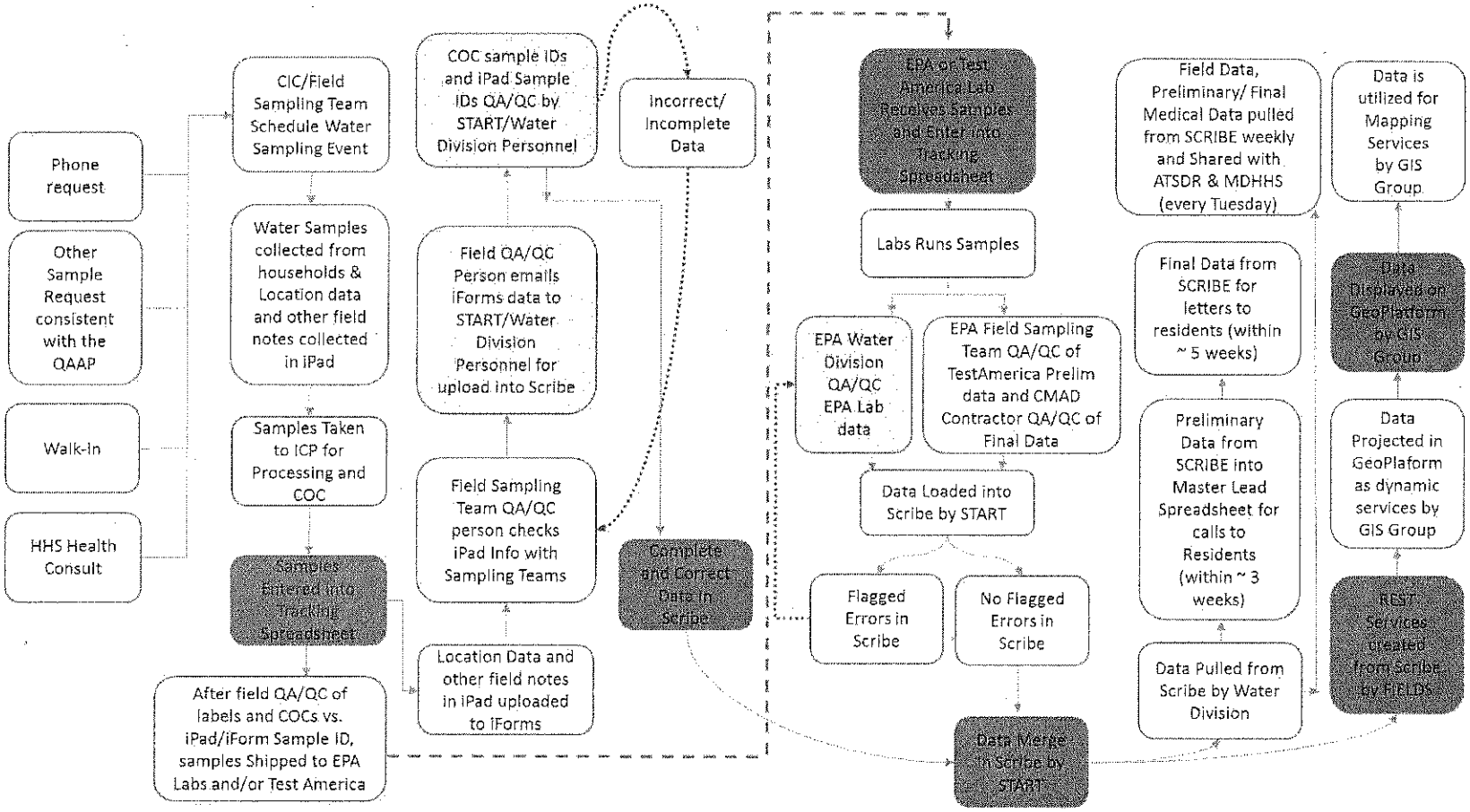
The sampling team will generate field records (either hard copy or electronic records) which will be utilized to document sampling activities and relevant observations. An electronic field record management system (using iPads and iForm software) has been developed for the project and should be used to document all field observations whenever possible. Electronic field records will be reviewed by the field sampling team, generally on the same day as sampling occurred, prior to uploading the field notes into the project Scribe database.

All laboratory data and analytical results will be stored in EPA laboratory information management systems (LIMS). The applicable EPA or contract laboratory will store this data in accordance with its standard data storage procedures. In addition, electronic data deliverables (EDD) compatible with the Scribe database will be provided for preliminary and final analytical results. Analytical results will be provided in .pdf electronic document read-only format and as an EDD. EDDs will be reviewed by the Water Division Technical Contacts (or designee such as Water Division QA personnel) prior to uploading preliminary and final analytical results into the project Scribe database. Data deliverables will also be provided in Excel format.

Preliminary analytical results will be provided by the EPA or contract laboratory to the EPA Water Division Technical Contacts as soon as feasible, within 6 business days after receipt of each shipment of samples. Final peer-reviewed analytical results will be forwarded from the EPA or contract laboratory to the EPA Water Division Technical Contacts and the Ground Water and Drinking Water Branch (GWDWB) Quality Assurance (QA) Coordinator, as soon as feasible, within 10 business days after preliminary analysis of each shipment of samples. The EPA Water Division Technical Contacts will arrange for archival of the final analytical reports in accordance with Federal Record retention schedules, and updating all data providers of changes to the distribution list for data deliverables.

All data will be validated as meeting laboratory and QAPP-defined quality control requirements by EPA and contract laboratories according to their procedures. In addition, the preliminary and final data files and associated lab reports will be compared for discrepancies and reviewed for missing samples or information by a team of Water Division Technical Contacts.

Data Flow Diagram – Flint Drinking Water Response



13. Data Assessment and Response Actions

Formal field audits by quality assurance personnel are not anticipated for this project. Identification of problems related to technical performance will be the responsibility of the technical staff working on this project.

The EPA Project Officer will assess any problems that arise in the field. If necessary, modifications to technical procedures may be considered. Any changes in technical procedures will be documented in the field notebook, evaluated to determine if there will be any impact to the data and then highlighted in the final project report.

Laboratory personnel will perform self-audits and institute corrective actions in accordance with their respective written procedures. Data review of all EPA or contract laboratory generated data is performed by a second analyst not associated with the actual measurement operations for the given analytical batch, but knowledgeable in the analytical processes employed. It is the responsibility of the reviewer to ensure that all data generated are correct and of known and documented quality. Once the review is completed, the reviewer will sign and date the appropriate Data Review checklist according to the EPA or contract laboratory SOPs. Any limitations on the use of data, e.g., data qualifiers, will be included in the final report for the project.

The Water Division Technical Contacts (or designee such as Water Division QA personnel) will perform a data quality assessment on the results of each batch of water samples, based on laboratory blanks, laboratory fortified blanks, and laboratory-fortified samples (i.e., matrix spikes). The Water Division Technical Contacts will review the analytical report and determine any limitations on the use of the data (see Section 6) and include these limitations in the final project report. If any data is assessed to be unusable by the Water Division Technical Contacts or Project Officer, re-sampling may be required.

14. Reporting, Documents, and Records

Original documents will be stored as detailed below.

	EPA Project Officer	EPA CRL	Other Laboratories
Analytical Request Form		XX	XX
QAPP	XX		
Field Records (Electronic or Hard Copy)	XX		
Certification of Sample Containers	XX	XX	
Chain-of-Custody	XX	XX	XX
Photos	XX		
Analytical Results	XX	XX	XX
Final Project Report	XX		

Project files will be kept for as long as Technical Assistance to City of Flint continues. The EPA Water Division Technical Contacts will arrange for archival of the final analytical reports in accordance with Federal Record retention schedules. Final analytical results will also be distributed to all relevant parties, provided to the applicable resident in accordance with Consumer Notification requirements, and posted on EPA's Flint Drinking Water Response website.

Photos will be stored as per the August 3, 2006 "Digital Camera Guidance for EPA Civil Inspections and Investigations". Photos will be downloaded onto a CD or DVD and stored with the project file at the EPA Region 5 Office.

15. Dispute Resolution

Quality assurance disputes regarding this QAPP will be brought to the attention of the GWDWB QA Coordinator, respective laboratory director, and the Water Division QA Manager. If a solution cannot be reached or agreed upon within three working days, the issue will be raised by either the GWDWB QA Coordinator, Water Division QA Manger, or the respective laboratory director to the Deputy Water Division Director, and if necessary, to the Water Division Director for final resolution.

Appendices

Appendix A – Faucet Filter Evaluation

Appendix B –Distribution System Monitoring for Disinfectant and DBPs
- Appendix B-1 – ORD Sampling Plan
- Appendix B-2 – TTHM and HAA9 Sampling Instructions

Appendix C – Lead Source/Release Diagnostic Evaluation
- Appendix C-1 Sequential Sampling Instructions to Residents
- Appendix C-2 Residential Sampling Volunteer Survey
- Appendix C-3 Plumbing Inspections for Corrosion Control Treatment Assessment

Appendix D – Health and Direct Contact Exposure Evaluation
- Appendix D-1 – Health and Direct Contact Exposure Evaluation, General Procedures
- Appendix D-2 – Limited "Pilot" Evaluation

Appendix E – Aerator Particulate Evaluation

Appendix F - Distribution System Monitoring for Treatment Assessment

Appendix G – Distribution System Sampling for Coliform Bacteria

Appendix H – Resident-Requested Sampling and Hot Water Evaluation

Appendix I – Lead Service Line Extraction and Pipe Scale Analyses

Appendix J – Sample Custody, Packaging, and Shipment
- Appendix J-1 – Chain-of-Custody Form
- Appendix J-2 – Sample Packing Instructions
- Appendix J-3 – Sample Shipment Instructions

Appendix A – Faucet Filter Evaluation Sampling

Water samples will be collected to assess concentrations of lead in filtered and unfiltered drinking water at selected sampling sites, including homes where existing analytical data indicates elevated lead in water concentrations above 150 µg/L. Field sampling coordinators will confirm the schedule with the applicable resident(s) in advance of sampling activities. In general, three grab water samples will be collected at the kitchen faucet at each selected sampling site:

- Filtered Water, Existing Faucet Filter - One grab sample will be collected through the existing water filter (if present). The field sampling coordinators will note the type (brand) of the filter, status of the filter indicator, and available information from the resident regarding the time since the filter or cartridge was installed.
- Unfiltered Water - The filter will be removed, and an unfiltered water sample will be collected as the first grab sample following removal of the filter and/or aerator. No cleaning or flushing will be conducted prior to the unfiltered water grab sampling.
- Filtered Water, New Faucet Filter - Following the collection of the unfiltered sample, a new filter or new filter cartridge will be installed, and the water will be allowed to run through the new filter for approximately two minutes. Following installation and flushing of the new filter or replacement filter cartridge, a grab sample will be collected through the newly installed filter.

No stagnation or flushing is generally required prior to grab sampling. If no faucet filter is currently in place at the site, or if a faucet filter is unable to be installed, the field sampling coordinators will collect fewer samples and will document reasoning in the field notes. All grab samples should be collected bypassing existing whole house filter(s) and/or water softeners. The sampling location (e.g., kitchen sink faucet) must be clearly documented in the field records.

Beginning in late March 2016, a modified procedure was implemented to include the collection of unfiltered samples following a minimum of 6 hours stagnation. The resident will be asked to record the time when water was last used in the home (i.e., no faucets, toilets, shower, bath tub, washing machine, dishwasher, and hose), and field sampling coordinators will record the total stagnation time in the field records. When stagnation can be confirmed, two water samples will be collected as described below at each selected sampling site, generally at the kitchen faucet.

- Unfiltered Water - The filter will be removed (or bypassed), and an unfiltered water sample will be collected as a first flush sample following removal of the filter and/or aerator and a minimum of 6 hours stagnation. No cleaning or flushing will be conducted prior to the unfiltered water grab sampling.
- Filtered Water, Existing (or New) Faucet Filter - One grab sample will be collected through the existing water filter (if present). If no existing filter is present, field sampling coordinators will install and flush a new filter, as described above, then collect the filtered water sample through the newly-installed water filter. The field sampling coordinators will note the type (brand) of the filter, status of the filter indicator, and available information from the resident regarding the time since the filter or cartridge was installed.

Beginning in May 2016, a similar procedure was implemented collect filtered and unfiltered samples at residences selected and referred by ATSDR and partner health agencies. At each sampling site, two water samples will generally be collected as described below, generally at the kitchen faucet.

- Unfiltered Water - The filter will be bypassed (or removed), and an unfiltered water sample will be collected. No cleaning or flushing will be conducted prior to the unfiltered water grab sampling.
- Filtered Water, Existing Faucet Filter - One grab sample will be collected through the existing water filter (if present). If no existing filter is present, field sampling coordinators will install and flush a new filter, as described above, then collect the filtered water sample through the newly-installed water filter. The field sampling coordinators will note the type (brand) of the filter, status of the filter indicator, and available information from the resident regarding the time since the filter or cartridge was installed.

If field sampling coordinators observe an expired filter, based on filter indicator light or other indicators, they will install a new filter and flush the new filter per field procedures described above. In those cases, a third sample would be collected as a filtered sample through the new filter.

For each grab water sample, one 1,000-mL HDPE bottle will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals including lead. Field sampling coordinators will be responsible to pack water samples and ship to the selected EPA laboratory or the PHILIS Contract Laboratory, as described in Appendix J.

Water sample identification will use the nomenclature below.

- Prefix of "FG" will indicate the sampling site was selected based on a previously reported lead in water concentration above 150 µg/L.
- Prefix of "FGW" will indicate the sampling site was selected based on the request of the resident or home owner.
- Prefix of "FH" will indicate the sampling site was selected by ATSDR and partner health agencies.
- Prefix of "FGC" will indicate the unfiltered sample is a first-flush sample collected following removal of the filter and/or aerator and a minimum of 6 hours stagnation.
- Numbers will be used to indicate unique samples.
- House letter unique to the address and sample type will be included following numbers.
- Suffix of "U" will indicate the sample is filtered water collected through an existing faucet filter.
- No suffix will indicate the sample is unfiltered water.
- Suffix of "N" will indicate the sample is filtered water collected through a newly installed faucet filter.

Unique sample identification will be required. Deviations from this sampling nomenclature must be clearly documented in the field records including hard copy field forms, electronic field forms, and/or chains of custody.

Field records should also include the following, to the extent information is provided by the resident or observed in the field:

- Interior plumbing including material (e.g., PVC, galvanized iron, copper, and/or lead), length, and diameter
- Service line including material (e.g., PVC, galvanized iron, copper, and/or lead), length, and diameter
- Estimated distance (or pipe length) between the sample tap and the distribution water main
- Filter(s) in use at the home, including any that were being used at the time of sampling
- Known physical disturbances such as recent road work or utility work that could disturb the service line near the sampling location
- Other relevant field observations such as activities completed at the home (e.g., flushing, aerator cleaning) and color, odor, or debris in the water
- Photographs of the sample tap(s) and underlying fixtures and components

Following the completion of grab sampling, field measurements for pH and chlorine residual may be collected as discussed in Section 5.6.

Before leaving the site, the field sampling coordinator should confirm the faucet filter is properly installed and returned to "Filter" mode (not "Bypass" mode). If time allows, the field sampling coordinator will work with residents to check and clean aerators on ALL other faucets in home.

Appendix B – Distribution System Water Quality Characterization

Chlorine, pH, and temperature will be measured weekly or biweekly at up to 35 representative sites in the distribution system in accordance with the sampling plan developed by ORD (see Appendix B-1).

Total trihalomethanes (TTHM) and nine haloacetic acids (HAA9) will be measured biweekly or monthly at up to 35 sites within the distribution system in accordance with sampling instructions provided by the contract laboratory (see Appendix B-2). The sample identification for all TTHM and HAA9 samples will use a unique station number (assigned to a specific sampling location, along with a prefix of "T" or "H" for TTHMs and HAA9 analysis, respectively. The sample identification will also include the station location as the sample date and the sample address in the following format: MMDDYYNNNNStreet, where MM is the calendar month, DD is the calendar date, YY is the calendar year, and NNNN is the house number for the identified street address. Trip blanks for TTHM analysis will be identified on the chains of custody using a prefix of "B". Field replicates will be identified on the chains of custody using a suffix of "D" (e.g., T12D would be a field replicate of sample T12).

Field sampling coordinators will confirm the schedule with the applicable resident(s) in advance of sampling activities. Field sampling coordinators will measure field water quality parameters including temperature, chlorine residual, and pH, immediately after sample collection, within 15 minutes. Field sampling coordinators will be responsible for obtaining and maintaining field water quality equipment (e.g., pH meter and colorimetric test kits for chlorine residual) and following manufacturer guidance to ensure accurate field measurements are obtained. Field sampling coordinators will record all equipment maintenance (including calibration) and field measurements for each sample in the field records.

Water samples for water quality parameters including TTHMs and HAA9 will be placed on in ice-packed coolers as soon as possible after collection. Field sampling coordinators will be responsible to pack distribution system samples for TTHMs and HAA9 and ship to the PHILIS Contract Laboratory, as described in Appendix J.

Appendix B-1 – ORD Sampling Plan

Flint Distribution System Chlorine Residual Sampling Plan

Introduction

In January 2016, a team of engineers with extensive experience in chlorine disinfection was requested to assess chlorine disinfection in the Flint, MI water distribution system to ensure best practices were being used, lowering risks from waterborne disease and ensuring proper health protection was being carried out through the use of disinfection in the public water system. The flint water system aligns pretty closely to city boundaries, as shown in Figure 1, with only a few hundred water customers outside these boundaries.

Through meetings with U.S. EPA staff already in Flint, meetings with Flint Water Utility Staff, and driving sampling sites throughout the city, it was quickly determined that additional chlorine monitoring was required in Flint. Through Legacy agreements between all the systems that receive Detroit water, the Michigan Department of Environmental Quality (MDEQ) has been implementing a modified monitoring plan for the Total Coliform Rule (TCR) (which includes chlorine monitoring) for the Detroit metropolitan area (which includes Flint, MI) in accordance with Section 141.29 (Monitoring of Consecutive Public Water Systems), since Michigan was granted primacy in 1978. While the Flint MI water system has been monitoring the full number of prescribed samples (100) per month, the number of monitoring sites is small (10), which is a result of the legacy agreements going back many years.

In light of the limited chlorine monitoring locations and some preliminary chlorine sampling conducted by both U.S. EPA and Flint community advocates that resulted in low chlorine concentrations, an organized repetitive chlorine sampling program was deemed necessary to establish the success of the current chlorination objectives being carried out in Flint, MI, and to work with the water utility to improve disinfectant residual maintenance and reduce risks of waterborne disease if low chlorine residuals are encountered in the distribution system.

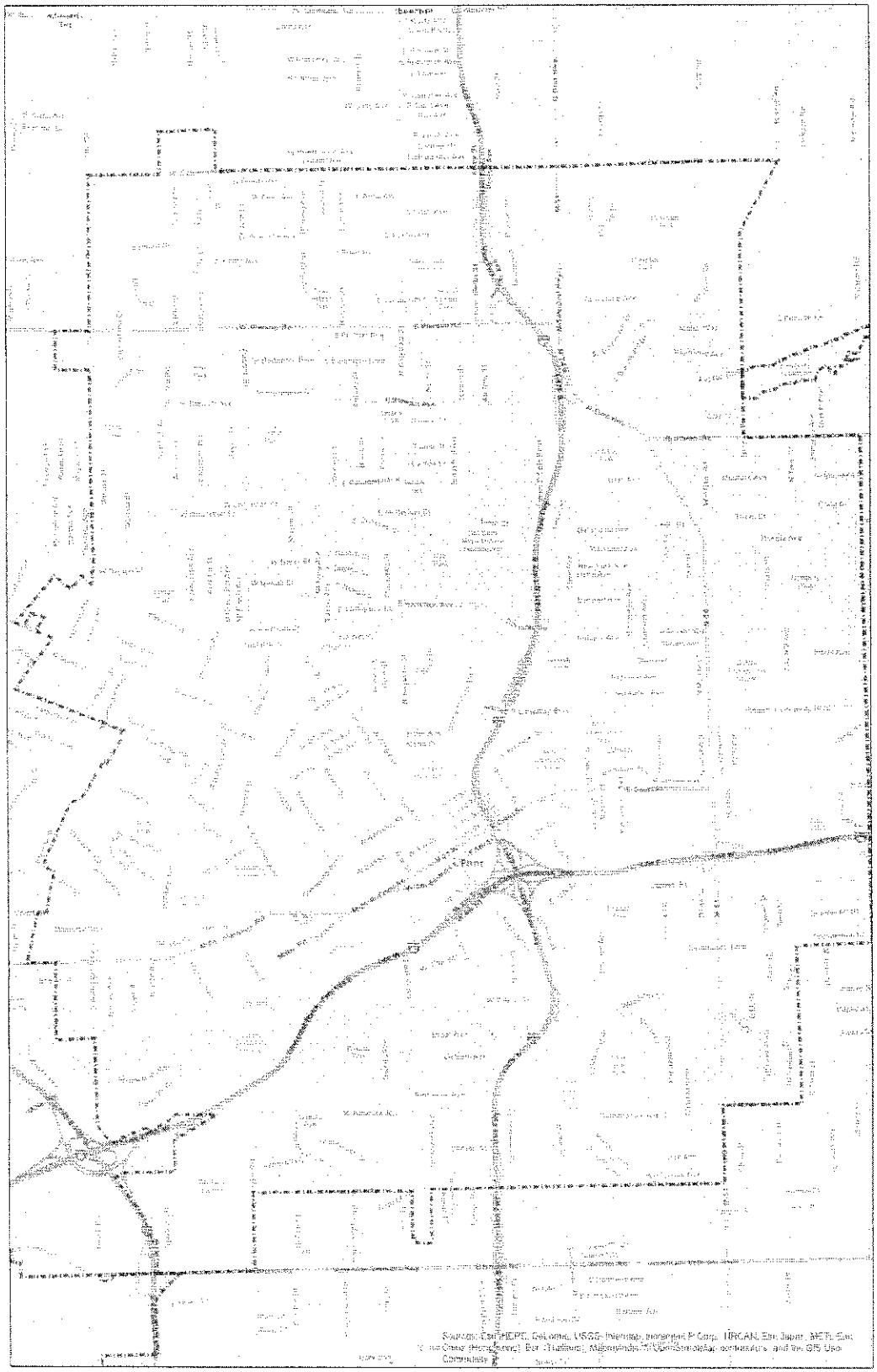


Figure 1 - City of Flint Map (dotted line is city boundary)

Sample Site Number Selection Methodology

Because of its service population of approximately 100,000 people, the City of Flint is required to collect 100 total coliform (TCR) samples each month (USEPA, 1989). Currently, the City of Flint accomplishes this by sampling the 10 sites listed in Table 1. In light of all that has been learned with regards to disinfection and distribution systems as chemical reactor systems since the late 1970s, monitoring 10 distribution sites in a system the size of Flint is not a current best practice for monitoring the maintenance of a residual disinfectant as a barrier to microbial contamination.

Table 1 – Existing City of Flint Total Coliform (TCR) Sample Site Locations

Location	Street	City	State	Zip Code
[redacted]	[redacted]	Flint	MI	48506
		Flint	MI	48503
		Flint	MI	48507
		Flint	MI	48505
		Flint	MI	48506
		Flint	MI	48504
		Flint	MI	48505
		Flint	MI	48532
		Flint	MI	48504
		Flint	MI	48504

Current best practice for a water utility the size of Flint (approximately 100,000 people) to ensure distribution system sampling represents the entire distribution system would be to organize the TCR sampling program to include 50 total sample sites, representing one-half of the total number of monthly required TCR samples. These 50 sampling sites would be used on a geographical rotating basis such that each sample location would be monitored twice monthly, resulting in the required 100 TCR samples. To this end, the City of Flint also currently monitors an additional 15 sites on a quarterly basis (Table 2), resulting in a total of 25 sample site locations that are currently monitored by the City of Flint on some interval.

Based on a desired target of 50 total sample site locations and the existence of 25 sample site locations, a target for this sampling site plan was to add an additional 20-25 sample site locations, bringing to the total number of sample site locations in the City of Flint to approximately the desired number of 50.

Table 2 - Existing City of Flint Quarterly Sample Site Locations

Location	Street	City	State	Zip Code
[redacted]	[redacted]	Flint	MI	48507
		Flint	MI	48504
		Flint	MI	48532
		Flint	MI	48502
		Flint	MI	48503
		Flint	MI	48506
		Flint	MI	48506
		Flint	MI	48503
		Flint	MI	485041
		Flint	MI	48507
		Flint	MI	48507
		Flint	MI	48503
		Flint	MI	48504
		Flint	MI	48503
		Flint	MI	48503

Sample Site Location Selection Methodology

Individual sample site locations were selected to assess chlorine residuals and potential microbial contamination at locations where existing sampling is not currently conducted by the City of Flint (i.e., sample locations presented in Table 1 and Table 2). Furthermore, the sampling site location selection focused on locations (1) serviced by smaller distribution mains (i.e., 8 inches or less in diameter) and (2) that are publicly accessible (e.g., schools, places of worship, community centers) throughout the City of Flint service area to allow for repeated sampling (e.g., weekly). Sampling locations were selected based on available distribution system layout records and known City of Flint total coliform rule (TCR) sampling locations. During sampling site selection, the site owner/manager was asked for their willingness to participate in the regular sampling effort, and sampling will be scheduled based on the location's availability to the extent feasible.

To assess the locations of smaller distribution mains, the best available record was a City of Flint water distribution system map from 1980 (Figure 2) that indicated all mains that were 8" or greater. A working sample site selection map (Figure 3) was then generated by combining (1) the distribution system map, (2) the City of Flint provided TCR sample site locations, and (3) a web-based search to determine publicly accessible sampling locations throughout the City of Flint. The working sample site selection map was then used to evaluate approximate 25 locations that provided a representative coverage of the City of Flint, and the extent possible, would be located on 8" or smaller distribution system mains where the City of Flint does not currently monitor water quality.

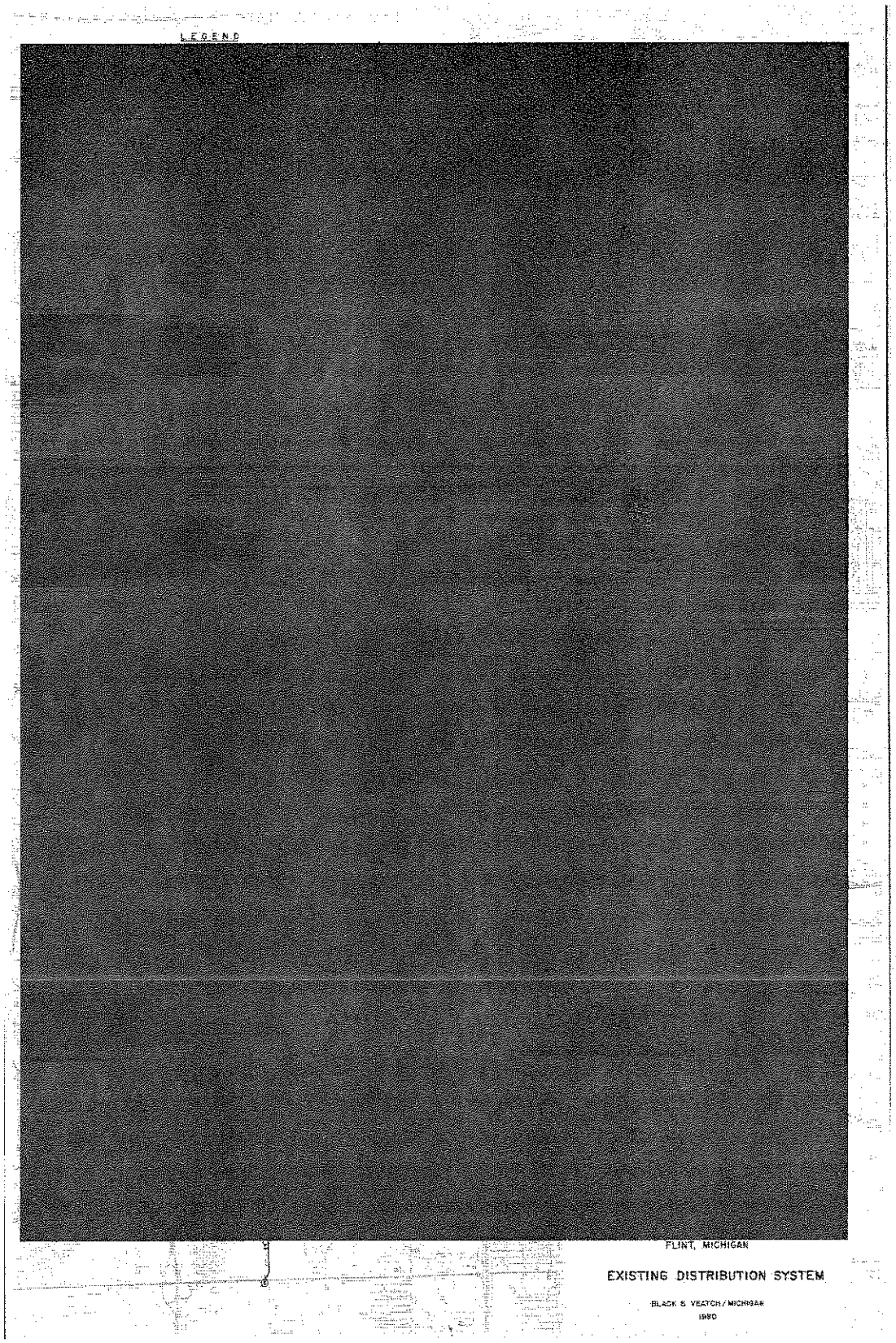


Figure 2 – City of Flint Water Distribution System Map from 1980

Potential Free Chlorine Sampling Sites in Flint, MI

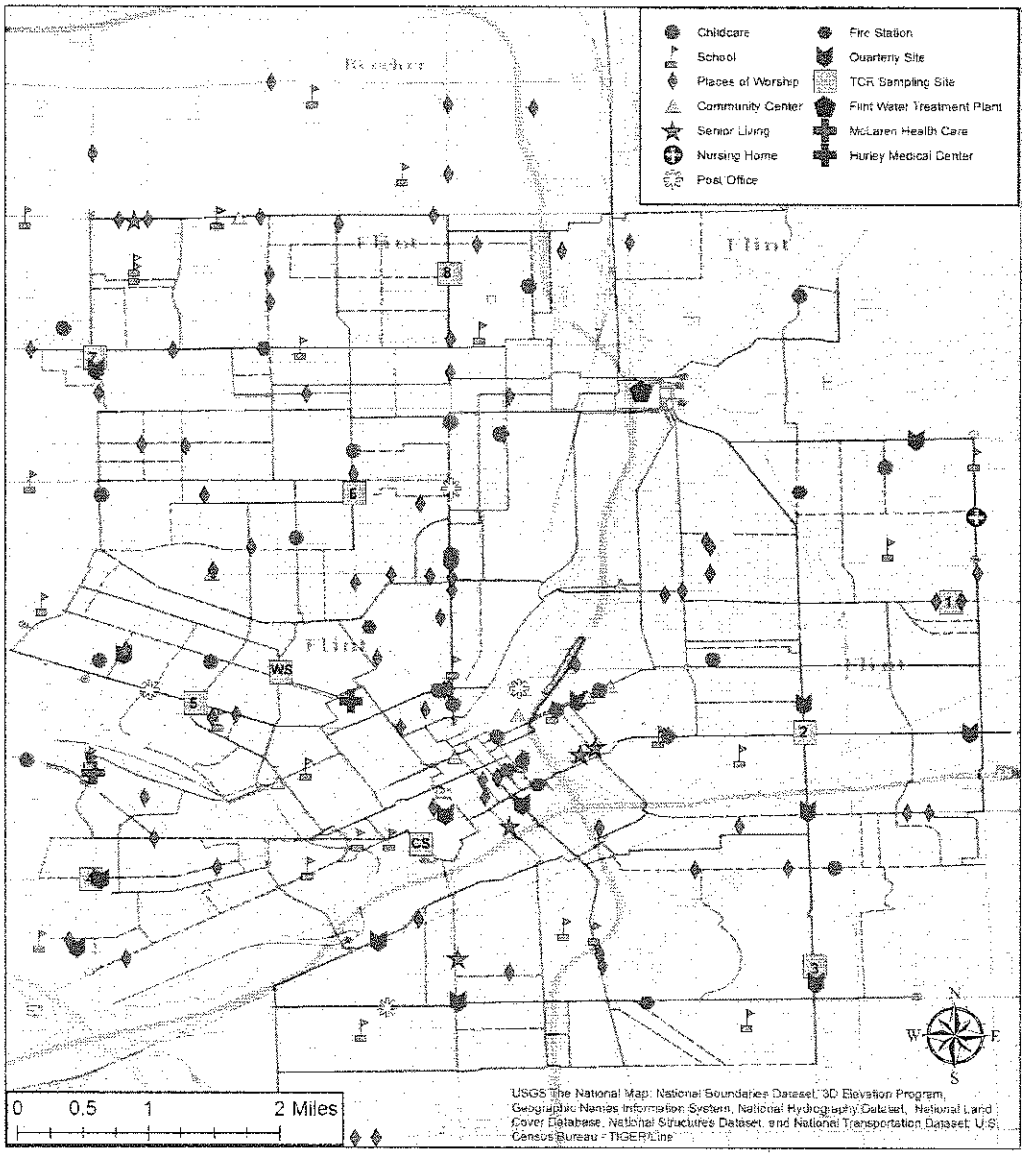


Figure 3 - Working Sampling Plan Site Selection Map

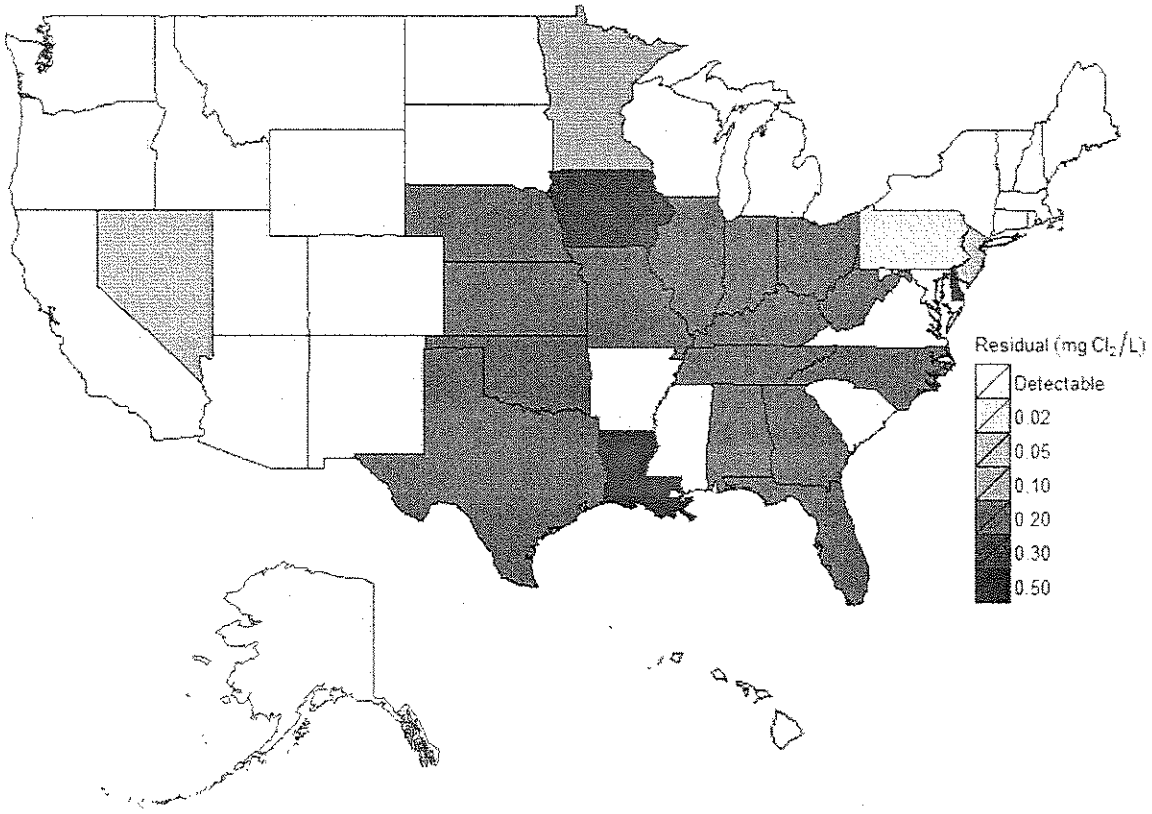
Sample Site Analysis Methodology

To assess the presence of a disinfectant residual in the main distribution system mains, residual chlorine, pH, and temperature will be immediately measured after sample collection (i.e., within 15 minutes), according to manufacturer guidance of the field instruments to ensure accurate field measurements are obtained. If a chlorine residual is measured less than 0.20 mg Cl_2/L, a microbial sample will also be collected. Specific procedures for microbial sampling are

provided in Appendix E, except that the flushing time may be greater than 5 minutes if this is required to guarantee sampling from the targeted distribution system main. The specific flushing time required for each sample location was determined as described in Flushing Methodology. The 0.20 mg Cl_2/L trigger for microbial sampling was selected because it represents (1) the performance goal for the Area-Wide Optimization Program's (AWOP) approach to maintaining distribution system water quality in free chlorine systems and (2) a common minimum distribution system level used across the country to ensure that a measurable residual is present (Figure 4), and (3) the minimum free chlorine residual in a water distribution system recommended in the Ten States Standards (Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2012). Furthermore, it is the goal of this sampling program to have chlorine residuals greater thean 0.2 mg Cl_2/L throughout the distribution system.

Sample Site Flushing Methodology

Required sample flush times were determined individually at each sample site location. The flushing objective was to displace the volume of water between the sample location and water distribution system main, ensuring that water samples were representative of water quality within the distribution system main. Required flush volumes were determined by measuring the length and diameter of individual segments of water line (i.e., water service line and premise plumbing). The total flush volume was determined by adding the calculated flush volume of each segment. The service line length was measured from the water main to the meter connection inside the building. The diameter of the service line was determined by inspecting the size of line entering the building prior to the meter connection. The premise plumbing length was estimated between the meter connection and the sampling location. In general, the sample site location nearest to the meter connection was selected. The diameter of premise plumbing was assumed to be ¾" when actual diameter was unknown. All line lengths were measured using a rolling measuring wheel. A conservative flowrate of 2 gpm was assumed at the majority of sample locations, although actual flowrates were greater. The conservative estimate was intended to provide a "factor of safety" to ensure that a sufficient volume of water was flushed prior to sample collection. Sample flush times were then calculated based on the estimated flush volume and assumed flowrate. In a few cases where calculated flush times were excessive (e.g., greater than 30 minutes), the actual flowrate was measured and flush times were adjusted. A minimum sample flush time of five minutes was conducted at all locations.



Cl_2—chlorine

- Colorado has proposed requiring a 0.2 mg Cl_2/L minimum residual throughout the distribution system.
- Iowa provides an exception for dead ends or areas that represent very low use.
- Louisiana requires a "detectable" residual but currently has an emergency rule requiring a minimum 0.5 mg Cl_2/L free chlorine residual; therefore, 0.5 mg Cl_2/L is used here.
- Minnesota requires a "detectable" residual but also requires measurement to the nearest 0.1 mg Cl_2/L in the range below 0.5 mg Cl_2/L; therefore, 0.1 mg Cl_2/L is used here.
- Nebraska allows a minimum 0.1 mg Cl_2/L free chlorine residual if additional conditions are met.
- Nevada requires a "detectable" residual but also requires measurement to the nearest 0.05 mg Cl_2/L; therefore, 0.05 mg Cl_2/L is used here.
- North Carolina's minimum residual included here is for Total Coliform Rule compliance samples. North Carolina requires a "detectable" residual at maximum residence times.
- Pennsylvania has proposed requiring a 0.3 mg Cl_2/L free chlorine residual.
- Vermont requires a "detectable" residual but further states that the residual "should be 0.1" mg Cl_2/L.

Figure 4 – United States minimum free chlorine residuals in the distribution system (not entering the distribution system) for Subpart H Surface Water Treatment Rule systems based on review of existing states' rules and regulations as of January 2015 (Wahman & Pressman, 2015)

Results of Site Selection Evaluation

Beginning with all the potential sites developed and mapped (Figure 3), a smaller subset of sites was chosen based on spreading the geographic location of sites throughout the city and on interest in capturing samples from embedded locations near homes which are most representative of where the water is consumed. The team canvassed the city over a one week period, evaluating sites for the repetitive sampling plan. Some sites were deemed unfeasible based on factors such as distance from the distribution main, size of service line, or ability to access the facility. For example, some locations with 4 or 6 inch service lines that are hundreds of feet from the street would require more than an hour of flush time, which is not feasible for this type of sampling program. Therefore, these sites were eliminated. By the end of the week, 24 sites were selected for the repetitive sampling program, as summarized in Table 3 and shown on Figure 5. These sites represent, when combined with the 10 TCR and 15 quarterly sites monitored by the city, good geographic distribution and representation from smaller distribution pipes not previously evaluated in the City's TCR and quarterly locations.

Table 3 - Selected Sample Site Locations

Location	Street	City	State	Zip Code
[redacted]	[redacted]	Flint	MI	48505
		Flint	MI	48505
		Flint	MI	48504
		Flint	MI	48503
		Flint	MI	48506
		Flint	MI	48506
		Flint	MI	48506
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		Flint	MI	48505

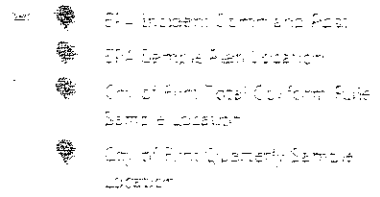


Figure 5 - Summary of Selected Sample Site Locations and Existing Total Coliform (TCR) Rule Sampling Site Locations

Data Collection, Analysis, and Operational Responses

The chlorine residual data collected for each time period will be shown on a map of the city and posted to the EPA Flint website. Methods for further data analysis as related to enhanced

visual communication of the information both inside and outside EPA are currently being evaluated. U.S. EPA is also working on obtaining and using an already developed distribution system network model, which when completed, will allow further advanced analysis of the measured chlorine residuals. Should low chlorine residual areas exist within the distribution system, U.S. EPA will work with the Flint Water Utility to implement appropriate measures to increase the chlorine residuals. Such measures may include, for example, low velocity flushing (to improve residual with minimal disturbances to scale) and adjusting chlorine additions at the City's chlorination points.

Sampling Plan Implementation

The chlorine sampling of the identified locations should be conducted initially on a weekly basis until the extent of any distribution system residual issues are identified and the initial remediation steps are initiated by working with the water utility. If availability of any sites becomes a problem, they will be replaced with new sites in nearby locations. Furthermore, additional sites may be added as necessary to fully assess chlorine residuals in the distribution system. Depending on whether problems are identified, this initial phase is to be a minimum of 4 weeks. Upon review of the data and changes to distribution system operations made in response by the water utility, an evaluation can be made after 4 weeks to determine if sampling can be extended to once every two weeks. This may be possible during later winter and early spring while the water is still cold.

Once spring and summer arrive and bring warmer water temperatures, the chlorine decay in the distribution system will tend to increase and could possibly result in more low chlorine residual problems in the distribution system. As this process begins to occur with warmer weather, sampling will likely need to be ramped back to a weekly basis. Through this process of sampling and evaluating time series data from representative locations throughout the city, the success of disinfection within the distribution system (and resulting risk reduction) of having a measurable chlorine residual throughout, can be evaluated. Ensuring proper health protection through chlorine disinfection is an immediate and acute need. However, there are other more chronic unintended consequences of modifying chlorination practices. The most direct consequence of changing chlorination practices is the resulting change in disinfection byproducts (DBPs). Therefore, DBPs, specifically the regulated trihalomethanes and haloacetic acids, will be added to the sampling routine as needed to characterize the concentrations of DBPs through the system and assess whether additional remediation activities are required to keep DBPs below regulated thresholds. Finally, large changes in water chemistry, such as adding significantly higher concentrations of chlorine, can affect pipe scale and inorganic metals concentrations; therefore, prior to making significant changes to current practices, the EPA Task Force experts will be consulted to ensure that everyone agrees on proposed changes to treatment and distribution.

References

Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2012. *Recommended Standards for Water Works*. Health Research Inc., Albany, NY.

USEPA, 1989. Drinking Water; National Primary Drinking Water Regulations; Total Coliforms (Including Fecal Coliforms and E. Coli); Final Rule. *Federal Register*, 54:124:27544.

Wahman, D.G. & Pressman, J.G., 2015. Distribution System Residuals-Is "Detectable" Still Acceptable for Chloramines? *Journal American Water Works Association*, 107:8:53.

Appendix B-2 – TTHM and HAA9 Sampling Instructions

SAMPLING INSTRUCTIONS

for

TRIHALOMETHANES and HALOACETIC ACIDS

TRIHALOMETHANES (THMs)

1. When sampling from a water tap, open the tap and allow the water to flow until the water temperature has stabilized (Usually about 3-10 minutes).
2. Adjust the flow to about 500 mL/minute and collect three vials of sample.
3. Each vial contains a Sodium Thiosulfate preservative, so do not rinse the vial. Fill the vials to overflowing but take care that the preservative is not rinsed out.
4. No air bubbles should pass through the sample as the vial is being filled or be trapped in the samples when the vial is sealed.
5. After sealing, the vial should be inverted a few times to make sure no bubbles have been trapped and to mix the preservative with the sample.
6. Samples must be chilled during storage and shipment to about 4°C and maintained at that temperature until analysis. Crushed ice should be used as blue ice typically cannot maintain a temperature of 4° C for an extended period of time.

HALOACETIC ACIDS (HAAs)

1. Fill sample bottles but take care not to flush out the ammonium chloride which, for a 250 mL bottle, is 25 mg of Ammonium Chloride dissolved in a small amount of water. Because the target analytes of this method are not volatile, it is not necessary to ensure that the sample bottles are completely headspace free.
2. When sampling from a water tap, remove the aerator. Open the tap and allow the system to flush until the water temperature has stabilized (usually about 3-10 minutes). Collect samples from the flowing system.
3. When sampling from an open body of water, fill a 1-quart wide-mouth bottle or 1 liter beaker with sample from a representative area, and carefully fill sample vials from the container.
4. After collecting the sample, seal the bottle and agitate by hand for 15 seconds.
5. Samples must be chilled to 10° C during storage and shipment. Crushed ice should be used as blue ice typically cannot maintain a temperature of 10° C for an extended period of time.

Appendix C – Lead Source/Release Diagnostic Evaluation

As discussed in Section 5.3, sequential water sampling will be conducted initially at approximately 100 sampling sites, then on an ongoing basis at approximately 45 single-family residences. Procedures for subsequent rounds of sequential sampling may be tailored for each single-family residence, based on available information including analytical results and plumbing information. In addition, smaller bottle sizes (e.g., 500-mL) may be used to further evaluate potential sources of lead in interior plumbing.

Field sampling coordinators will confirm the schedule with the applicable resident(s) in advance of sampling activities. At each sampling site, the kitchen sink faucet will be identified, where water is drawn for human consumption (drinking, cooking, formula preparation, etc.). For the first round of sequential sampling, any existing filter must be removed from the faucet prior to flushing or sampling. For the second round of sequential sampling, existing filters will be bypassed, rather than removed, to assess whether high results are from lead sources in specific locations or from sporadically released particulate from unknown locations. At least 6 hours prior to sampling (i.e., the night before), the resident will flush the sample tap for 5 minutes and then assure that water is not used overnight. The resident will be asked to record the time at which flushing was completed and when water was last used in the home (i.e., no faucets, toilets, shower, bath tub, washing machine, dishwasher, and hose), and field sampling coordinators will record the total stagnation time in the field records. Appendices C-1 and C-2 provide example forms for communication with residents during scheduling and upon mobilization to the sampling site.

After at least 6 hours of stagnation time, two 125-mL water samples and then approximately 15 sequential 1,000-mL water samples will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals including lead [tin will be added to the list of parameters to be analyzed starting with second round of sequential sampling in May 2016]. The total number of 125-mL, 500-mL, and 1,000-mL water samples will be selected by the field sampling coordinators, depending on the lengths and diameters of plumbing materials to the water main. Field sampling coordinators should also determine whether any water outlet (whether or not they are used for human consumption) is leaking. Repairs should be made to the leaking outlets prior to beginning sampling. All sequential samples should be collected after removing any existing kitchen faucet filter and/or aerator and bypassing existing whole house filter(s) and/or water softener(s). The sampling location (e.g., kitchen sink faucet) must be clearly documented in the field records.

The procedures below will be followed for sequential sampling, and any deviations will be noted in the field records.

- Place the open bottles in order by sample number (S01 125-mL HDPE bottle, S02 125-mL HDPE bottle, subsequent 500-mL HDPE bottles for interior plumbing volumes, and/or subsequent 1,000-mL HDPE bottles for plumbing and/or service line volumen) and remove the caps from all bottles so that all of the bottles are ready to fill.
- Record the beginning sample date/time.

- Begin by placing the Sample 1 bottle under the faucet and open the cold water slowly until the faucet is fully open. Beginning with the second round of sequential sampling, place the Sample 1 bottle under the filter bypass and open the water slowly until the faucet is fully open. While one bottle is filling, grab the next bottle so that you are ready to move it under the faucet quickly. Collect the samples without shutting off the water in between samples, and try not to let any water spill in between samples.
- Once the bottle is filled, quickly place the Sample 2 bottle under the faucet, and continue until you have filled all sample bottles.
- Once all sample bottles have been filled, place the caps tightly on all sample bottles.
- Record the final sample date/time.
- Fill in the highlighted areas of the Chain-of-Custody form and sign/date the form when the samples are relinquished for shipping.

Following the completion of sequential sampling, field measurements for pH and chlorine residual and water sampling for laboratory analysis of total metals, total phosphorous, alkalinity, chloride, sulfate, and fluoride may be collected as discussed in Section 5.6 and listed below.

- DS01 - One 125-mL HDPE bottle will be collected for analysis of total phosphorus, field-preserved (H_2SO_4 to pH<2) within 15 minutes of sampling.
- DS02 - One 125-mL, unpreserved HDPE bottle will be collected for analysis of alkalinity and anions (sulfate, chloride, fluoride).
- DS03 - one 1,000-mL HDPE bottle will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals including lead.

Field sampling coordinators will be responsible to pack water samples and ship to the selected EPA laboratory, as described in Appendix J. Samples for total phosphorus (DS01) and anions/alkalinity (DS02) will be placed in an ice-filled cooler following sampling and shipped on ice. Water sample identification will include the nomenclature below.

- A prefix of "S" will indicate sequential samples with the subsequent numbers indicating the order of sampling.
- The prefix of "DS" will indicate distribution system samples, generally collected after approximately 5 minutes of flushing, with subsequent numbers indicating total phosphorus analysis (01), alkalinity and anions (02), and total metals (03).
- House letter unique to the address and sample type will be included following numbers.
- The date (or a number indicating the sampling round) may be appended as a suffix for subsequent resampling at a given sampling location. For example, "S2" and "DS2" will be used to indicate second-round sequential samples.

Unique sample identification will be required. Deviations from this sampling nomenclature must be clearly documented in the field records including hard copy field forms, electronic field forms, and/or chains of custody.

Field records should also include the following, to the extent information is provided by the resident or observed in the field:

- Water meter reading
- Interior plumbing including material (e.g., PVC, galvanized iron, copper, and/or lead), length, and diameter
- Service line including material (e.g., PVC, galvanized iron, copper, and/or lead), length, and diameter
- Estimated distance (or pipe length) between the sample tap and the distribution water main, including distances to the curb, shut-off, and/or water meter
- Filter(s) in use at the home, including any that were being used at the time of sampling
- Known physical disturbances such as recent road work or utility work that could disturb the service line near the sampling site
- Other relevant field observations such as activities completed at the home (e.g., flushing, aerator cleaning) and color, odor, or debris in the water
- Photographs of the sample tap(s) and underlying fixtures and components

Before leaving the site, the field sampling coordinator should confirm the faucet filter is properly installed and returned to "Filter" mode (not "Bypass" mode). If time allows, the field sampling coordinator will work with residents to check and clean aerators on ALL other faucets in home.

Following the review of initial sequential sampling results, EPA may return with licensed plumbers to initial sequential sampling sites to collect additional plumbing information for further evaluation of analytical results and identification of LSL sites. Plumbing information will be recorded in the field records, using electronic field forms when possible. Appendix C-3 includes an example form for plumbing inspection.

Appendix C-1 Sequential Sampling Instructions to Residents

Sequential Sampling Instructions

Please read all instructions at least one day prior to scheduled sampling.

• Use only the kitchen faucet for all of these samples. **Remove any point-of-use filter from the faucet prior to flushing or sampling.**

• **If there is a filter** - The night before sampling (right before everyone goes to bed), remove any point-of-use filter from the faucet.

• The night before sampling (right before everyone goes to bed) run the water from the kitchen faucet for at least 5 minutes, so that sequential sampling provides representative information on the sources of lead for each specific volume of water.* **Write down the date/time you finished running the water.**

• **Do not use ANY water from the home plumbing for at least 6 hours prior to samples being collected the following morning**. Specifically, do not shower, flush toilets, wash laundry, or use other water taps. Any automatic lawn sprinkler systems should also be turned off. It may help to tape a sign in the kitchen and bathrooms with a reminder not to use the water, in case people forget. If water is accidentally used, please notify EPA so that resampling can be considered.

*NOTE: As EPA and others have reported, the practice of "pre-flushing" can result in underestimation of lead in water exposure when using a single 1,000-mL "first-draw" sample for Lead and Copper Rule compliance monitoring. Because relatively clean water from the water main is flushed through the service line and premise (interior) piping, a single 1,000-mL "first-draw" sample will only capture lead contributed by the portions of the premise (interior) piping closest to the faucet. For homes with lead service lines, significant lead exposure may be present but not captured by the single 1,000-mL "first-draw" sample, especially if "pre-flushing" is used.

By comparison, this study uses sequential water sampling, which collects volumes of water that capture lead contribution from sequential segments of the premise and service line piping (i.e., first bottle captures water that has been sitting overnight in piping nearest the faucet, and subsequent bottles capture water farther away towards the water main). By flushing the lines prior to sequential sampling, the lead contribution from individual pipe segments can be more easily distinguished.

Appendix C-2 Residential Sampling Volunteer Survey

Residential Water Sampling Survey		
Owner Name:		**Owner Occupied? (Y/N)**
Occupant Name:		
Address:		
City/Town:		
State/Zip Code:		
Contact Phone:		
Type of Structure:	☐ Single-Family Residence ☐ Multiple Family Residence (e.g. apartment building) ☐ Commercial Structure Year structure was built, if known: _____	

Do you have any leaking faucets anywhere in the residence? If yes, where is the leaking faucet located?	**Yes** ☐ **No** ☐
Do you have a water softener in your home?	**Yes** ☐ **No** ☐
Do you use a water filter installed on your home plumbing? If yes, where is it located?	**Yes** ☐ **No** ☐
Has there been any plumbing work done in your home in the last 6 months, such as new faucets, fixtures, pipe replacement or repair, water meter installation, and so on?	**Yes** ☐ **No** ☐

If there has been plumbing work done in the past six months, please explain the work briefly below, including the specific locations where the work was done and when it was done. In addition, if the plumbing material in the residence is known, please describe it below:

Appendix C-3 Plumbing Inspections for Corrosion Control Treatment Assessment

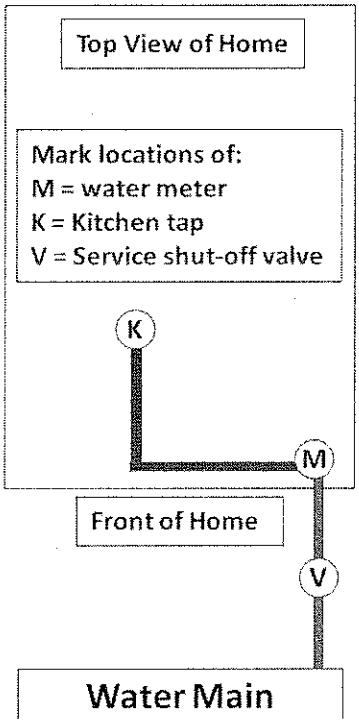
EPA has completed sequential sampling at approximately 100 homes that have previously tested high for lead in the water. The objective of the plumbing inspections is to identify homes which have lead service lines and a variety of plumbing materials commonly found in homes for use in assessing the progress of corrosion control treatment.

In order to properly assess the effectiveness of the corrosion control treatment for the variety of plumbing materials commonly found in homes, the goal is to identify 15 homes in each of three plumbing categories (galvanized iron pipe, copper pipe and plastic pipe). Based on the results of the plumbing inspections and other information, EPA will select 45 homes for conducting sequential sampling every two months to assess lead levels.

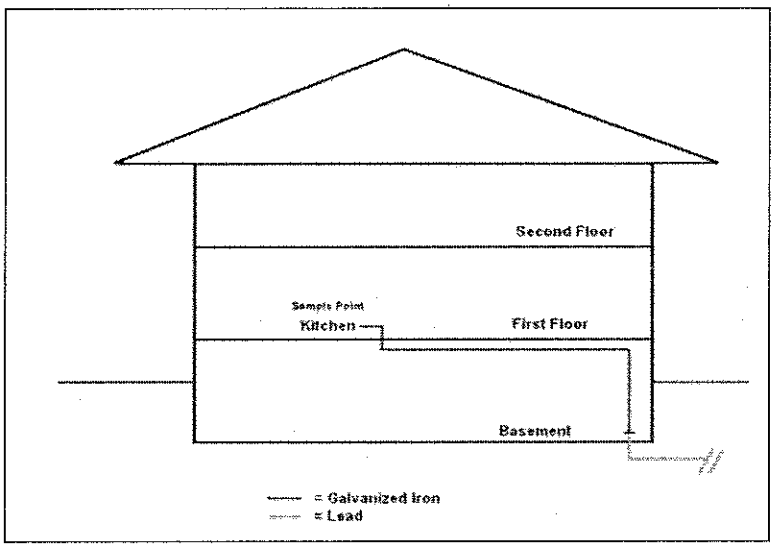
Information to be collected includes the water main location, service line information, and internal (home) plumbing information.

Beginning with the service line entering the home, note the material and pipe diameters and measure the length of pipe for each pipe segment from the service line inlet to the kitchen tap. Note any connectors, valves, and fittings at the end of each segment. Also note the location, make and model of any water treatment units connected to the plumbing from the service line inlet to the kitchen tap.

EXAMPLE TOP VIEW



EXAMPLE FRONT VIEW



EXAMPLE COMPLETED FORM

Resident Information		
Name: Samantha Smith	Address: 1415 W. Main St Flint, MI xxxxx	Phone: (810) xxx-xxxx
Plumber(s): Sam Stone	Phone #(s): (810) xxx-xxxx	

Water Main Location		
Note whether the water main is located on the same (near) side as the home (N) or on the far side across the street (F)	N__X__ F____	

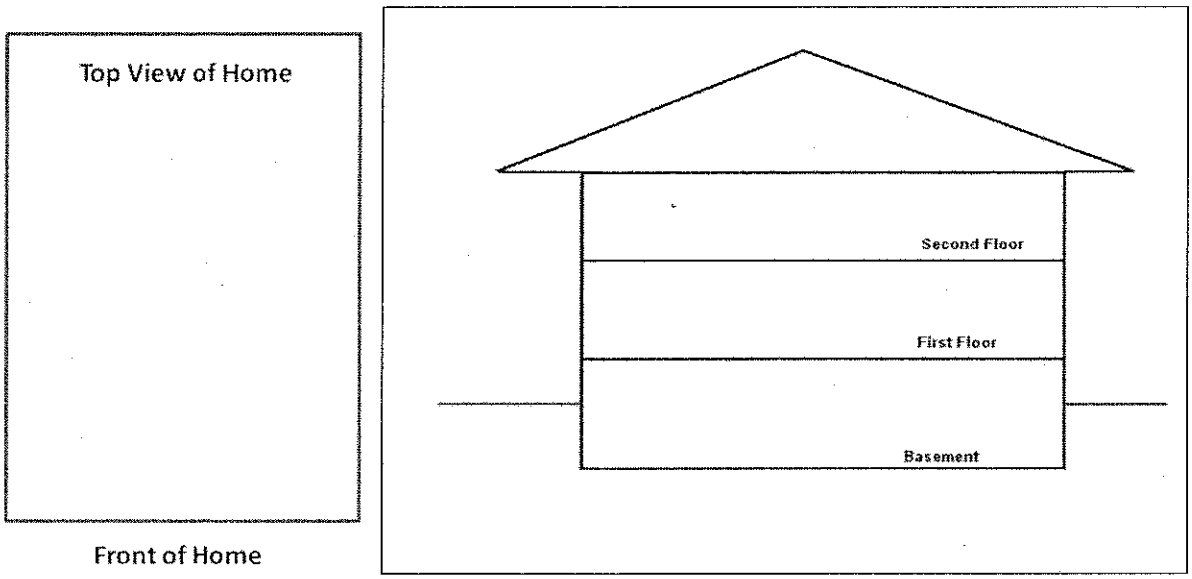
Service Line Information			
*Please use the following abbreviations for all plumbing information: L = Lead, C = Copper, G = Galvanized Iron, P = Plastic, B = Brass			
For the information below, list the source of information used, such as City of Flint or other plumbing records, visual inspection, etc.	*Material	Pipe Diameter (inches)	Length (inches)
Service line material, pipe diameter and length of pipe from water main to service shut-off. Information Source: City of Flint records	Unknown	Unknown	224
Service line material, pipe diameter and length of pipe from service shut-off into home Information Source: Visual inspection	L	1 inch	630

Internal (Home) Plumbing Information				
*Please use the following abbreviations for all plumbing information: L = Lead, C = Copper, G = Galvanized Iron, P = Plastic, B = Brass, S = stainless steel				
Pipe Segment	*Material	Pipe Diameter (inches)	Length (inches)	Note all connectors, valves, and other plumbing components
1	L	1 inch	6 inches	Lead service line comes into home and runs 6 inches to brass shut-off valve.
2	C	1 inch	12 inches	Copper pipe from shut-off valve to water meter.
3	C	1 inch	65 inches	Copper pipe from water meter to brass shut-off valve.
4	C	½ inch	200 inches	Copper pipe to brass shut-off valve under sink.
5	SS	¼ inch	16 inches	Stainless steel tube from shut-off valve to faucet connection.

Plumbing Inspection Form

General Location of Sampling Tap

Using the home diagrams at the bottom of the page, draw the plumbing path from the service line inlet to the kitchen tap as shown in the two example diagrams (top view and front view) above.



Water Main

Information to be collected using the form below includes the water main location, service line information and internal (home) plumbing information. Beginning with the service line entering the home, note the material and pipe diameters and measure the length of pipe for each pipe segment from the service line inlet to the kitchen tap. Note any connectors, valves, and fittings at the end of each segment. Also note the location, make and model of any water treatment units connected to the plumbing from the service line inlet to the kitchen tap.

Should you have any questions, please contact _____

Plumbing Inspection Form, continued

Resident Information		
Name:	Address:	Phone:
Plumber(s):	Phone #(s):	

Water Main Location		
Note whether the water main is located on the same (near) side as the home (N) or on the far side across the street (F)	N____ F____	

Service Line Information

*Please use the following abbreviations for all plumbing information:
L = Lead, C = Copper, G = Galvanized Iron, P = Plastic, B = Brass

For the information below, list the source of information used, such as City of Flint or other plumbing records, visual inspection, etc.	*Material	Pipe Diameter (inches)	Length (inches)
Service line material, pipe diameter and length of pipe from water main to service shut-off. Information Source: _____			
Service line material, pipe diameter and length of pipe from service shut-off into home Information Source: _____			

Internal (Home) Plumbing Information

Beginning with the service line entering the home, note the material and pipe diameters and measure the length of pipe for each pipe segment from the service line inlet to the kitchen tap. Note any connectors, valves, and fittings at the end of each segment. Also note the location, make and model of any water treatment units connected to the plumbing from the service line inlet to the kitchen tap.

*Please use the following abbreviations for all plumbing information:
L = Lead, C = Copper, G = Galvanized Iron, P = Plastic, B = Brass, S = stainless steel

Pipe Segment	*Material	Pipe Diameter (inches)	Length (inches)	Note all connectors, valves, and other plumbing components
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Appendix D – Health and Direct Contact Exposure Evaluation

EPA will coordinate with Michigan Department of Health and Human Services (MDHHS) and Agency for Toxic Substances and Disease Registry (ATSDR) to collect grab water samples from selected locations including bathroom faucet(s), bathtub tap(s), shower head(s), and kitchen faucets at homes selected by MDHHS and ATSDR.

Appendix D-1 – Health and Direct Contact Exposure Evaluation, General Procedures

EPA will coordinate with Michigan Department of Health and Human Services (MDHHS) and Agency for Toxic Substances and Disease Registry (ATSDR) to collect grab water samples from selected locations including bathroom faucet(s), bathtub tap(s), shower head(s), and kitchen faucets at homes selected by MDHHS and ATSDR.

Field sampling coordinators will confirm the schedule with the applicable resident(s) in advance of sampling activities. Several samples will be collected at each location at the discretion of the field sampling coordinators, generally following the nomenclature and bottle types listed below. No stagnation or flushing is required prior to grab sampling. Field sampling coordinators will also record additional field observations including the presence and descriptions of any color, odor, and sediment or debris in the water from each tap sampled. Grab samples should generally be collected after removing any aerator or faucet filter and bypassing existing whole house filter(s) and/or water softeners. If a faucet filter is currently in use at the sampling site, field sampling coordinators may collect additional filtered water sample(s) and document the sample collection methods in the field records. The sampling location (e.g., kitchen sink faucet) must be clearly documented in the field records. A house letter unique to the address and sample type will be included following numbers.

- Kitchen sink faucet (cold water samples)
  - R01 - one 1,000-mL HDPE bottle will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals (long list – see Section 9.1) and hardness
  - R02 - one 125-mL, unpreserved HDPE bottle will be collected for analysis of alkalinity and anions (sulfate, chloride, fluoride)
  - R03 - one 125-mL, unpreserved HDPE bottle will be collected for analysis of TDS
- Bathroom sink faucet (cold water sample)
  - R04 - 1,000-mL HDPE bottle will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals (long list – see Section 9.1) and hardness
- Bathtub faucet (cold water sample)
  - R05 - 1,000-mL HDPE bottle will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals (long list – see Section 9.1) and hardness
- Shower faucet (cold water sample)
  - R06 - 1,000-mL HDPE bottle will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals (long list – see Section 9.1) and hardness
- Bathtub or Shower faucet, whichever is used more (hot water samples)
  - R07 - one 1,000-mL HDPE bottle will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals (long list – see Section 9.1) and hardness
  - R08 - one 125-mL, unpreserved HDPE bottle will be collected for analysis of alkalinity and anions (sulfate, chloride, fluoride)
  - R09 - one 125-mL, unpreserved HDPE bottle will be collected for analysis of TDS

Unique sample identification will be required, and sample times should be recorded for each sample bottle. Deviations from this sampling nomenclature must be clearly documented in the field records including hard copy field forms, electronic field forms, and/or chains of custody.

Field measurements for pH, chlorine residual, turbidity, and conductivity will be collected from cold water at the kitchen faucet after grab sampling and flushing for an additional 3 more minutes. If no kitchen faucet is currently in use at the sampling site, field sampling coordinators may collect additional field measurements and document the sample collection and location in the field records. Field sampling coordinators will measure field water quality parameters including chlorine residual, pH, conductivity, immediately after sample collection, within 15 minutes. Field sampling coordinators will also measure turbidity within 48 hours. If a turbidimeter is not available for field measurement, an additional unpreserved 125-mL sample may be collected and shipped for laboratory analysis within the 48 hour hold time. Field sampling coordinators will be responsible for obtaining and maintaining field water quality equipment (e.g., pH meter, conductivity meter, turbidimeter, and colorimetric test kits for chlorine residual) and following manufacturer guidance to ensure accurate field measurements are obtained. Field sampling coordinators will record all equipment maintenance (including calibration) and field measurements for each sample in the field records.

At the direction of MDHHS and ATSDR, turbidity, conductivity, and total dissolved solids were discontinued at the end of March 2016.

Field records should also include the following, to the extent information is provided by the resident or observed in the field:

- Interior plumbing including material (e.g., PVC, galvanized iron, copper, and/or lead), length, and diameter
- Service line including material (e.g., PVC, galvanized iron, copper, and/or lead), length, and diameter
- Estimated distance (or pipe length) between the sample tap and the distribution water main
- Filter(s) in use at the home, including any that were being used at the time of sampling
- Known physical disturbances such as recent road work or utility work that could disturb the service line near the sampling site
- Other relevant field observations such as activities completed at the home (e.g., flushing, aerator cleaning) and color, odor, or debris in the water
- Photographs of the sample tap(s) and underlying fixtures and components

Water samples for the assessment of health and direct contact exposure evaluation, including for analysis of TDS (and turbidity, if applicable), will be placed in ice-packed coolers as soon as possible after collection. Field sampling coordinators will be responsible to pack samples and ship to the applicable EPA or contract laboratory, as described in Appendix J. Due to short hold times, any turbidity samples must be shipped overnight on the same date as collection.

Before leaving the site, the field sampling coordinator should confirm the faucet filter is properly installed and returned to "Filter" mode (not "Bypass" mode). If time allows, the field sampling coordinator will work with residents to check and clean aerators on ALL other faucets in home.

Request Letter from MDHHS

STATE OF MICHIGAN
DEPARTMENT OF HEALTH AND HUMAN SERVICES
LANSING

RICK SNYDER
GOVERNOR

NICK LYON
DIRECTOR

January 28, 2016

[redacted]
U.S. Environmental Protection Agency
[redacted]

RE: Pilot public health response for rash complaints received from city of Flint water users (i.e., Pilot Rash Response)

Dear [redacted]

This letter is a request for technical assistance in collecting water samples from homes in the Flint area that are on city of Flint water users where residents are reporting rashes. The details of this request are stated below. The US EPA technical assistance will be in collaboration with MDHHS pilot public health response to residents with reported rashes. Information from this effort will be used in collaboration with the US EPA, CDC, ATSDR and MDHHS as they continue to develop a more comprehensive epidemiologic-based public health response.

As discussed earlier today, here is the intended process:

Objectives

1. MDHHS will interview resident to gather additional information on their complaint.
2. US EPA will conduct water sampling to get initial characterization of water as described below.

Scheduling Visits

MDHHS-DEH will schedule visits with residents. Currently, we have three appointments scheduled for Friday, January 29, 2016. The exact times of the appointments are still to be coordinated with the US EPA sampling team. MDHHS-DEH staff will be present with the EPA during sampling and will interview the resident.

Sampling Locations

MDHHS will rely on EPA OSC expertise to provide a uniform grab sample collection process. Grab samples will not necessary represent worst case metals concentrations, as the water will not necessary represent 6-hours of stagnant water prior to collection. Location of grab samples from indoor water sources may include, but are not limited to, shower heads, bath tub faucets, bathroom faucets, and kitchen faucets. Consultation with the resident will assist in identifying faucets to sample. Each water sample must be given a unique identification code and information recorded on the bottle needs to include sample location within the home, type of water tap, the

sample volume, with or without filter, order of sample collection, hot or cold water, date, time, and address.

Field - Direct Read Measurements

MDHHS request the following, to the best of EPA's immediately available resources:

- pH
- free chlorine
- color
- turbidity (if available)
- conductivity/TDS (if available)

Record any odor characteristics and visual observations (e.g. sediment), if relevant.

If possible, collect sample for (either direct read or for lab analysis)

- Hardness

Laboratory Metal Analysis

- Please confirm with US EPA laboratory, that the appropriate method is US EPA Method 200.8 for inorganics
  - *Method for Determination of Metals in Environmental Samples, Supplement I,* U.S. Environmental Protection Agency, Method 200.8, 1999 Revision 5.5.
  - MDHHS is most interested the metals: Cr, Cu, Fe, Pb, Ni, Zn
  - MDHHS would like the full list metals analyzed, if possible:

Analyte	Chemical Abstract Services Registry Number
Aluminum	7429-90-5
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Boron	7440-42-8
Cadmium	7440-43-9
Chromium	7740-47-3
Copper	7440-50-8
Iron	7439-89-6
Lead	7439-92-1
Manganese	7439-96-5
Mercury	7439-97-6
Molybdenum	7439-98-7
Nickel	7440-02-0
Selenium	7782-49-2
Silver	7440-22-4
Tin	7897-37-2
Thallium	7440-28-0
Uranium	7440-61-1
Vanadium	7440-62-2
Zinc	7440-66-6

Sampling Processing and Handling

MDHHS requests US EPA handle sample collection, processing, and shipment of samples to US EPA Region V Laboratory for analysis.

Data Management, Evaluation, and Reporting

MDHHS will work with EPA, CDC and ATSDR to determine data management, evaluation, and reporting. MDHHS will report results and interpretation back to the resident.

Thank you for your consideration of this requests. For questions, please contact either [redacted]

Sincerely,

[redacted]
Michigan Dept of Health and Human Services (MDHHS)
[redacted]

Appendix D-2 – Limited "Pilot" Evaluation

EPA will coordinate with MDHHS and ATSDR to collect grab water samples from homes selected by MDHHS and ATSDR to compare water quality at homes with reported health concerns in comparison to homes without health concerns. These water samples will be evaluated for an extended list of organic compounds including volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), and disinfection byproducts (DBP). Sampling procedures were approved by MDHHS and ATSDR, and analytical methods, analyte lists, and detection limits were selected by MDHHS and ATSDR.

Field sampling coordinators will confirm the schedule with the applicable resident(s) in advance of sampling activities. At least 6 hours prior to sampling (i.e., the night before), the resident will assure that water is not used overnight. The resident will be asked to record the time at which flushing was completed and when water was last used in the home (i.e., no faucets, toilets, shower, bath tub, washing machine, dishwasher, and hose), and field sampling coordinators will record the total stagnation time in the field records.

At each selected sampling site, water samples will be collected from a bathtub faucet at two temperatures: cold water and hot water (maximum temperature after running the hot water for approximately one minute). For each water temperature, the following water samples will be collected and analyzed by a contract laboratory:

- Total Metals (one 1,000-mL wide mouth bottle, field-preserved with nitric acid) for analysis using EPA Method 200.7/200.8 (long list – see Section 9.1)
- VOCs including THMs (three 40-mL vials, Teflon-capped, ascorbic acid pre-dosed and field-preserved with hydrochloric acid, zero headspace, and ice), for analysis using EPA Method 524.2
- DBPs General List (three 60-ml vials, Teflon-capped, ammonium chloride and phosphate buffer pre-dosed and field-preserved with zero headspace and ice), for analysis using EPA Method 551.1
- Chloral Hydrate (two 60-mL vials, Teflon-capped, sodium sulfite and phosphate buffer pre-dosed and field-preserved with zero headspace and ice), for analysis using EPA Method 551.1
- HAAs (one 250-mL amber glass bottle, ammonium chloride pre-dosed and field-preserved with ice), for analysis using EPA Method 552.3
- SVOCs (two 1,000-mL amber glass bottles, sodium sulfite crystals pre-dosed and field-preserved with ice), for analysis using EPA Method 525.2

In addition, field measurement of temperature will be collected and recorded (for both cold water and hot water) following filling all bottles.

Samples for VOC analysis will be filled slowly to reduce loss of volatiles and to prevent overfilling. Field sampling coordinators will wear gloves during sampling to protect from acid preservative, and any droplets that fall while closing the zero-headspace bottles will be rinsed down the drain as a safety measure.

Unique sample identification will be required, and sample times should be recorded for each sample bottle. Deviations from the sampling nomenclature indicated below must be clearly documented in the field records including hard copy field forms, electronic field forms, and/or chains of custody:

- Suffix of "RP" will indicate the sampling site was selected by MDHHS and ATSDR, based on health concern information provided by the resident.
- Suffix of "RPC" will indicate the sampling site was selected as a control site by MDHHS and ATSDR; available information indicates there are no health concerns at these sites.
- House letter unique to the address and sample type will be included following numbers.
- Numbers will be used to indicate unique samples:
    - RP01 (or RPC01) – Cold water (first flush) sample for total metals (long list – see Section 9.1)
    - RP02 (or RPC02) – Cold water (first flush) sample for VOCs including TTHMs
    - RP03 (or RPC03) – Cold water (first flush) sample for DBPs general list
    - RP04 (or RPC04) – Cold water (first flush) sample for Chloral hydrate
    - RP05 (or RPC05) - Cold water (first flush) sample for HAAs
    - RP06 (or RPC06) - Cold water (first flush) sample for SVOCs
    - RP07 (or RPC07) – Hot water sample for total metals (long list – see Section 9.1)
    - RP08 (or RPC08) – Hot water sample for VOCs including TTHMs
    - RP09 (or RPC09) – Hot water sample for DBPs general list
    - RP10 (or RPC10) – Hot water sample for Chloral hydrate
    - RP11 (or RPC11) - Hot water sample for HAAs
    - RP12 (or RPC12) - Hot water sample for SVOCs
- Trip blanks for VOC and TTHM analysis will be included in each shipment and identified on the chains of custody (e.g. "Blank").

Field records should also include the following, to the extent information is provided by the resident or observed in the field:

- Interior plumbing including material (e.g., PVC, galvanized iron, copper, and/or lead), length, and diameter
- Service line including material (e.g., PVC, galvanized iron, copper, and/or lead), length, and diameter
- Estimated distance (or pipe length) between the sample tap and the distribution water main
- Filter(s) in use at the home, including any that were being used at the time of sampling
- Known physical disturbances such as recent road work or utility work that could disturb the service line near the sampling site
- Other relevant field observations such as activities completed at the home (e.g., flushing, aerator cleaning) and color, odor, or debris in the water
- Photographs of the sample tap(s) and underlying fixtures and components

Water samples, including for analysis of VOCs, SVOCs, and DBPs, will be placed in ice-packed coolers as soon as possible after collection. Field sampling coordinators will be responsible to pack samples and ship to the applicable contract laboratory, as described in Appendix J.

Following the completion of grab sampling, field measurements for pH and chlorine residual may be collected as discussed in Section 5.6.

If time allows, the field sampling coordinators will work with residents to check and clean aerators on ALL other faucets in home.

Appendix E – Aerator Particulate Evaluation

During scheduled sampling events at selected locations with previously reported high lead results, field sampling coordinators may collect scale and debris that has accumulated on aerators and water filter screens.

Solids samples will be collected at the discretion of field sampling coordinators and only if sufficient solid material is present behind the aerator and/or water filter screen at a given sampling location. Photographs will be taken onsite of the scale/debris on the aerators and screens, and field observations will be recorded.

Because aerator particulate sampling will generally be conducted while at a sampling site for other sampling activities under this QAPP, the sample nomenclature and field notes will be as discussed in those respective sampling instructions (Appendices A through H). Aerator particulate samples will include a sample identification suffix of "AP". Unique sample identification will be required.

For each solid sample, one unpreserved glass or HDPE bottle will be used to collect as much particulate as possible for analysis of total metals including lead. Field sampling coordinators will be responsible to pack solid samples and ship to the PHILIS Contract Laboratory, as described in Appendix J.

Appendix F - Distribution System Water Quality Assessment for Treatment Assessment

Distribution system water quality assessment sampling may be conducted sampling sites after the completion of other sampling activities including sampling faucet filter evaluation (Section 5.1), health and direct contact exposure evaluation (Section 5.4), and resident-requested sampling (Section 5.8) and following sequential sampling for lead source/release diagnostic evaluation (Section 5.3), as specified below.

- Field water quality measurements for pH and chlorine residual will be collected and recorded following other grab sampling and sequential sampling activities.
- Water samples for laboratory analysis of total phosphorous, alkalinity, chloride, sulfate, fluoride, and total metals will be collected following sequential sampling, using the nomenclature in Appendix C (copied below). Unique sample identification will be required.
    - DS01 - One 125-mL HDPE bottle will be collected for analysis of total phosphorus, field-preserved (H_2SO_4 to pH<2) within 15 minutes of sampling.
    - DS02 - One 125-mL, unpreserved HDPE bottle will be collected for analysis of alkalinity and anions (sulfate, chloride, fluoride).
    - DS03 - one 1,000-mL HDPE bottle will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals including lead.

Distribution system water quality sampling will be conducted following at least 5 minutes of flushing, depending on the size and length of plumbing between the sampling location and the water distribution main. All grab samples should be collected bypassing existing whole house filter(s) and/or water softeners. The sampling location (e.g., kitchen sink faucet) must be clearly documented in the field records.

Field sampling coordinators will measure chlorine residual and pH immediately after sample collection, within 15 minutes. Field sampling coordinators will be responsible for obtaining and maintaining field water quality equipment (i.e., pH meter and colorimetric test kits for chlorine residual) and following manufacturer guidance to ensure accurate field measurements are obtained. Field sampling coordinators will record all equipment maintenance (including calibration) and field measurements for each sample in the field records.

Field sampling coordinators will preserve all total phosphate samples with one or two drops concentrated sulfuric acid to a pH below 2 SU immediately after sample collection (i.e., within approximately 15 minutes). Sulfuric acid, nitric acid, and narrow-range pH paper will be provided by EPA CRL.

Water samples for water quality parameters including total phosphorous, alkalinity, chloride, sulfate, and fluoride will be placed on in ice-packed coolers as soon as possible after collection. Field sampling coordinators will be responsible to pack distribution system water quality characterization samples and ship to the EPA CRL, as described in Appendix J.

Before leaving the site, the field sampling coordinator should confirm the faucet filter is properly installed and returned to "Filter" mode (not "Bypass" mode).

Appendix G – Distribution System Sampling for Coliform Bacteria

Distribution system sampling for Total Coliforms and *E. Coli* will be conducted at single-family residences with low chlorine residual measured during other sampling activities (see Section 5.2 and Section 5.6). Water samples will be preserved and transported as soon as possible (due to short hold time) after collection for analysis by a partner laboratory such as Genesee County.

Field sampling coordinators will confirm the schedule with the applicable resident(s) in advance of sampling activities. At each selected sampling site with previously measured low chlorine residual, field sampling coordinators will collect water samples from the kitchen sink cold water tap after flushing water for approximately 5 minutes. After flushing water from the sample tap for approximately 5 minutes, Coliform bacteria sample containers will be collected to assess water quality in the distribution main at each sampling site. No stagnation period is needed prior to flushing or water quality characterization sampling.

Samples will be collected in sterile 125-mL plastic bottles, placed in an ice-filled cooler, and transported directly (on the same day as sampling occurs) to the laboratory for analysis of Coliform bacteria. Samples will be preserved in the field or at the laboratory using sodium thiosulfate. Samples will be cooled to <10 °C (<50 °F) but not allowed to freeze.

Sampling Instructions

Wear gloves when collecting samples. Do not rinse the bottles. The bottles are sterile, so care must be taken not to contaminate the bottle or cap. Once the distribution line is flushed and the flow reduced, quickly open the bottle (but do not set the cap down), hold the cap by its outside edges only, and fill the sample bottle to just above the 100-mL line, leaving approximately one inch headspace. Cap the bottle immediately and place it into a cooler with ice for delivery or overnight shipment to the laboratory.

Holding Times

Maximum holding time for samples is 30 hours. Deliver samples to the lab the day of collection if possible or ship via overnight delivery.

Trip blanks may analyzed per the standard operating procedure of the laboratory.

When choosing sampling locations, field sampling coordinators will avoid these sampling sites for Total Coliform, if possible:

- Outdoor faucets
- Faucets connected to cisterns, softeners, pumps, pressure tanks or hot
- Water heaters
- New plumbing & fixtures or those repaired recently
- Faucets that hot & cold water come through
- Threaded taps
- Swing spouts
- Faucets positioned close to sink or ground

- Leaky faucets

Additional tips on collecting samples for Coliform bacteria:

- remove any attachments on the faucet
- allow water to flow for 5 or 6 minutes before sampling
- do not rinse or overfill container
- always collect cold water; never sample hot water
- do not touch the inside of the sample bottle or its cap

Appendix H – Resident-Requested Sampling and Hot Water Evaluation

Water samples may be collected at selected sampling sites at the request of residents. At least 6 hours prior to sampling (i.e., the night before), the resident will record the time at which flushing was completed and when water was last used in the home (i.e., no faucets, toilets, shower, bath tub, washing machine, dishwasher, and hose), and field sampling coordinators will record the total stagnation time in the field records.

In general, two grab water samples will be collected at the kitchen faucet at each selected resident-requested sampling site, using the sample identification nomenclature listed below. A house letter unique to the address and sample type will be included following numbers.

- G01 (unfiltered cold water sample) – After at least 6 hours of stagnation, one 1,000-mL HDPE bottle will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals, including lead, in first-draw unfiltered cold water.
- G02H (unfiltered hot water sample) – After the cold water sample is collected, the hot water tap will run until the water is hot. Then, one 1,000-mL HDPE bottle will be collected and field preserved (HNO_3 to pH<2) for analysis of total metals, including lead, in unfiltered hot water.

Field sampling coordinators will confirm the schedule with the applicable resident(s) in advance of sampling activities. Any faucet filter or aerator will be removed prior to sampling, and all samples should be collected bypassing existing whole house filter(s) and/or water softeners. The sampling location (e.g., kitchen sink faucet) must be clearly documented in the field records. Unique sample identification will be required. Deviations from this sampling nomenclature must be clearly documented in the field records including hard copy field forms, electronic field forms, and/or chains of custody.

While on-site, the field sampling coordinators will collect information regarding the hot water tank and the resident's willingness to participate in hot water evaluation sampling from their water tank.

- Determine if homeowner would allow a return visit and assist in sampling tank;
- Take picture of hot water tank including information on the water tank tag and condition/configuration/location of drain; and
- Ask owner for estimated age of hot water tank, identify any periodic maintenance, and record information in tablet.

At selected locations, field sampling coordinators may return to collect hot water samples from the hot water tank drain, as discussed below. Hot water tank sampling sites will be selected based on the following criteria: (1) homeowner would like a sample of the hot water tank water, (2) if homeowner is willing to open valve, and (3) the tank appears to be in good condition.

- G03HWT (unfiltered hot water sample from hot water tank drain) – Homeowners will voluntarily open the hot water tank valve and fill one HDPE bottle (125-mL or 1,000-mL, depending on clearance between the valve and the floor) will be collected. Field sampling

coordinators will field preserve (HNO_3 to pH<2) the hot water tank sample for analysis of total metals, including lead.

Field sampling coordinators will be responsible to pack water samples and ship to the selected EPA laboratory, as described in Appendix J.

Field records should also include the following, to the extent information is provided by the resident or observed in the field:

- Interior plumbing including material (e.g., PVC, galvanized iron, copper, and/or lead), length, and diameter
- Service line including material (e.g., PVC, galvanized iron, copper, and/or lead), length, and diameter
- Estimated distance (or pipe length) between the sample tap and the distribution water main
- Filter(s) in use at the home, including any that were being used at the time of sampling
- Known physical disturbances such as recent road work or utility work that could disturb the service line near the sampling site
- Other relevant field observations such as activities completed at the home (e.g., flushing, aerator cleaning) and color, odor, or debris in the water
- Photographs of the sample tap(s) and underlying fixtures and components

Following the completion of sampling, field measurements for pH and chlorine residual may be collected as discussed in Section 5.6.

Before leaving the site, the field sampling coordinator should confirm the faucet filter is properly installed and returned to "Filter" mode (not "Bypass" mode). If time allows, the field sampling coordinator will work with residents to check and clean aerators on ALL other faucets in home.

Appendix I – Lead Service Line Extraction and Pipe Scale Analyses

In order to inform corrosion control treatment optimization decisions, segments from four LSLs will be extracted and used for assessing the current condition and composition of the scales within the LSLs. Pipe scale analyses on segments of these pipes will be used to determine the type of scales have formed inside the lead lines under different chlorine levels and water quality conditions.

Four full LSLs will be identified by EPA ORD and the Task Force for initial extraction, including two sites in low chlorine areas and two sites in high chlorine areas. Based on ORD's assessment of the 5 full LSL addresses provided by EPA and the 37 full LSL addresses from MDEQ, evaluations are being conducted on LSL locations in comparison to the following chlorine data sources:

- 4 years of Flint water Utility Total Coliform Rule chlorine data from 10 sites
- Chlorine data from the 24 EPA chlorine monitoring locations (see Section 5.4)
- All chlorine screening data collected by the lead sampling teams (see Section 5.6)

Two 4-foot segments from each LSL will be carefully extracted, packed and shipped to EPA ORD for scale analyses. If possible, the extracted segments should be driven back to EPA ORD to avoid physical disturbances during shipping. Depending on the suitability and condition of the extracted LSLs, additional LSLs may need to extracted using the procedures outlined in this appendix. The sections below discuss EPA and City of Flint activities associated with LSL extraction and pipe scale analysis.

EPA Activities

Prior to extraction of the LSL, sequential sampling and WQP monitoring should be conducted at each of the four identified LSL sites in accordance with Appendix C.

Following the extraction of each LSL and the subsequent installation of new service lines at each site, EPA will conduct thorough whole-home flushing at all taps for at least 5 minutes, beginning with the tap closest to the point at which the service line comes into the home. Aerators should be removed and cleaned while the taps are being flushed.

Residents should also be provided with a water filter and replacement cartridge.

Following the replacement of the LSL and whole-home flushing, a final round of sequential sampling will be conducted in accordance with Appendix C.

Once post-replacement sample results are received, the residents will be provided with test results and explanation of the results.

City of Flint Activities

Two 4-foot segments would be extracted from each site identified in the above summary, then packed and delivered to EPA ORD (Cincinnati) for pipe scale analyses as specified below.

Documentation/Sample Tracking

Each pipe segment should be clearly labeled with the address of the site, the removal date, the installation date or year (if known) and a unique sample identification number (e.g., 314-1, 314-2). The addresses and other personally identifiable information will not be shared outside EPA except under an appropriate data sharing agreement.

Pipe Extraction Procedures

The location of each extracted pipe segment should be recorded in terms of distance from the water main.

The orientation of each pipe segment must be maintained during extraction so that the direction of water flow (arrow pointing from the water main into the home) can be clearly marked on each pipe segment.

It is important to maintain the physical integrity of the scales within the LSLs to be extracted. Pipes should not be extracted using cable tools. Proper equipment and procedures should be utilized in the excavation and extraction of the LSLs to avoid damage to the scales within the LSLs. Where possible, surface material (asphalt, cement, etc.) should be cut rather than jackhammered to avoid vibration and jarring of LSLs which can dislodge the scale within the LSLs. Excavation of subsurface down to the LSLs should be done carefully to avoid the same.

For each extracted pipe, two 4-foot long sections should be carefully cut using a rotary cutting tool. Electric saws or other tools that would vibrate the pipe should not be used.

- Pipes should not be bent during extraction, or in preparation for transport or to fit any shipping container.
- Pipes should be physically cut, not crimped on the ends.
- Short moist sponges should be inserted in the ends of the pipes before capping ends of each pipe segment to retain moisture.
- Each end of the pipe segments should be sealed using plastic inserts or plastic caps and taped securely in place on each end.
- Pipe segments should be packed such that the pipe sections do not shift or move inside the container during shipment (e.g., stiff thick-walled cardboard mailing tubes with bubble-pack)
- Where the LSL is connected to different components or connections, the LSL on either end of the component(s)/connection(s) or other pipe junctions of dissimilar metals should be preserved intact for shipment to EPA ORD with the pipe segments for scale analyses. These connection points are analyzed to determine if the water chemistry produces evidence of actual galvanic corrosion. Similar to the LSL segments, these pipes should be physically cut, not crimped on the ends. Short moist sponges should be inserted in the ends of the pipes

before capping ends of each pipe segment to retain moisture and each end of the pipe segments should be sealed using plastic inserts or plastic caps and taped securely in place on each end.

The extracted LSL segments will be sent to Kirk Sheckel at EPA ORD (Cincinnati) for sample analysis by various elemental and spectroscopic techniques in accordance with the Quality Management Plan for Research at the Advanced Photon Source of the Argonne National Laboratory, included below.

Pipe Scale Analysis and Evaluation: Quality Management Plan for Research at the Advanced Photon Source of the Argonne National Laboratory

Appendix J – Sample Custody, Packaging, Shipment, and Analysis

Proper packing and shipping is critical to ensuring samples reach the laboratory in good condition. If samples are damaged or the shipping company will not deliver the samples (such as if the water/ice leaks), resampling may be requested.

Whenever possible, overnight shipment will be on the same day as sampling is completed. All samples MUST be shipped overnight to arrive Monday through Friday or hand-delivered. No deliveries are accepted on weekends or Federal holidays. Exceptions may be made on a case by case basis dependent on sampling priority/emergency status.

An example Chain of Custody is provided in Appendix J-1. Sample packing instructions are provided in Appendix J-2. Laboratory addresses and sample coordinator contacts are provided in Appendix J-3 for shipment of samples.

Reporting limits and detection limits for EPA and contract laboratory analyses are summarized in Appendix J-4.

Appendix J-1 – Chain-of-Custody Form

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

REGION 5
77 West Jackson Boulevard
Chicago, Illinois 60604

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME					NO. OF CON-TAINERS	Analyte:						Activity Code:
SAMPLERS: *(Print Name and Sign)*													
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION								TAG NUMBERS

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*		Ship To:
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*		ATTN:
Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Airbill Number
				Chain of Custody Seal Numbers

Distribution: White - Accompanies Shipment; Pink - Coordinator Field Files; Yellow - Laboratory File

Printed on Recycled Paper/Printed with Soy-Based Ink

Appendix J-2 – Sample Packing Instructions

Supply list:

- Sturdy cooler(s)
- Heavy-duty, 30-gallon trash bags (2 per cooler)
- Absorbent material, suggested
- Bubble-wrap style materials, suggested (required if any glass sample bottles are to be shipped)
- **For shipment of sample bottles for analysis of organics (including VOCs/TTHM, HAA9, DBPs, and SVOCs), total phosphorus, TDS, and anions/alkalinity (see Sections 5.2, 5.4, and 5.6):** Fresh ice, approximately 15-25 pounds of ice per large cooler – at least 1/3 of the airspace of the cooler should be ice-filled during moderate weather; more ice should be used if weather is hot (80 F or hotter). Sample containers should be stored on ice as soon as possible after collection. If samples must be held more than a few hours before shipping, fresh ice may be needed for shipping.) – **not required for metals sample bottles**
- Filled and labeled sample bottles, with all lids tightly closed
- Sampling form(s) and chain-of-custody form(s)
- Zip-type plastic bags (Freezer style is best) such as Ziploc (1 per cooler)
- Shipping tape
- Completed shipping labels, with pouches if needed (1 per cooler)
- Paper towels

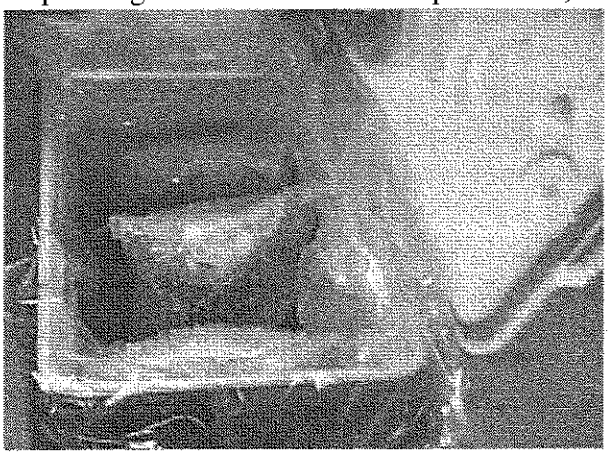
Cooler Packing Instructions:

1. Begin with a dry, study cooler. If the cooler has a drain, the drain should be closed and taped shut.
2. If available, place the dry absorbent material in the bottom of the cooler.
3. If available, place dry bubble wrap in the bottom and along the sides of the cooler.

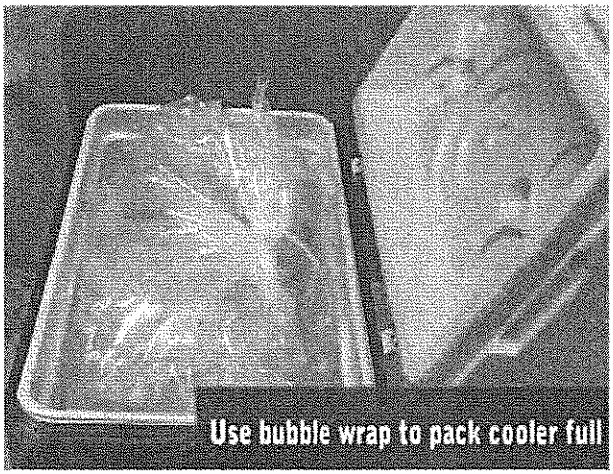
4. Open one of the trash bags. Place the trash bag inside the cooler as a liner.
5. **If the cooler will contain sample bottles for analysis of organics, total phosphorus, TDS, and anions/alkalinity:** Place 1-2 inches of ice inside the trash bag along the

bottom of the cooler. Take care to avoid getting any ice outside the trash bag. Ice may be omitted for coolers containing only metals samples.

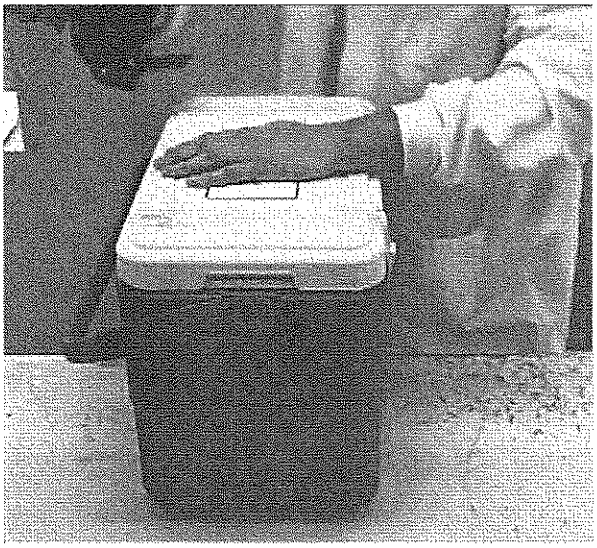
6. Open the second trash bag. Place the trash bag inside the first trash bag (lining the cooler again, but with any ice between the two bags).
7. Place sample bottles upright in the bottom of the cooler (inside both trash bags). If needed, dry off the sample bottles before placing them inside the dry trash bag. Depending on the number of sample bottles, additional cooler(s) may be needed.



8. Double check the chain-of-custody form against the labels and number sample bottles in the specific cooler. If more than one cooler is used, the chain-of-custody form(s) should match the contents of the individual cooler.
9. Place the chain-of-custody form(s) and sampling form(s) corresponding to the samples in the cooler inside a sealed Zip-type plastic bag.
10. After confirming the contents of the cooler, tie the second (inside) trash bag shut, taking care to press out excess air from the bag. Do not use drawstrings, use the sides of the trash bag to tie the bag shut securely. Check that the cooler lid is able to close (rearrange samples or remove excess air as needed).
11. **If the cooler will contain sample bottles for analysis of organics, total phosphorus, TDS, and anions/alkalinity:** Place 2-3 inches of ice on top of the closed second (inside) trash bag, inside the first (outside) trash bag. Take care to avoid getting any ice in the bottom of the cooler outside the trash bags.
12. Tie the first (outside) trash bag shut, taking care to press out excess air from the bag. Do not use drawstrings, use the sides of the trash bag to tie the bag shut securely. Check that the cooler lid is able to close (rearrange samples, shake ice to fill space between samples, and/or remove excess air as needed).
13. If the cooler is not full, use additional packing materials (i.e., bubble wrap) to fill remaining airspace.



14. Tape the sealed Zip-type plastic bag to the top inside of the cooler. This bag should contain the chain-of-custody form(s) and sampling form(s) corresponding to the samples in that cooler.
15. Shut the cooler lid (there should be no gap) and use packing tape to bind the cooler shut. Packing tape should make two to three full passes around the cooler at two different places.



16. Affix the shipping form to the outside of the cooler.
17. Drop off the cooler at the shipping vendor (e.g., FedEx) before the last pick-up for the day.

    If the cooler will contain sample bottles for analysis of organics, total phosphorus, TDS, and anions/alkalinity: If the last pick-up is missed, the cooler should be repacked with fresh ice.

Photo credit: https://www.youtube.com/watch?v=iSO7gjD5KF0 (Pace Analytical Services: How to Pack a Cooler)

Appendix J-3 – Sample Shipment Instructions

In general, send all samples to:

Robert Snyder
US EPA Region 5
Chicago Regional Laboratory
536 S. Clark Street, 10th Floor
Chicago, IL 60605

Before shipping samples, please notify the CRL Sample Coordinator (312-353-9078, Thompson.robert@epa.gov) to arrange for sample receipt.

If faster turn-around time is needed, an alternative qualified laboratory may be used. Field personnel should notify the Water Division Technical Contacts if this is needed. The alternative laboratories listed below have been identified for potential analysis of certain project samples; sample shipment instructions are provided below.

- Region 1 (metals analysis, as needed)

  Samples Receiving / Dan Boudreau
  US EPA New England Regional Laboratory
  Office of Environmental Measurement & Evaluation
  11 Technology Drive
  Chelmsford, MA 01863-2431

  Before shipping samples to Region 1, please notify the Region 1 Sample Coordinator (Doris Guzman, 617-918-8618, guzman.doris@epa.gov) to arrange for sample receipt.

- Region 4 (metals analysis, as needed)

  Samples Receiving / Jeffrey R. Hendel
  U.S. EPA - Region 4 Laboratory
  980 College Station Road
  Athens, GA 30605

  Before shipping samples to Region 4, please notify the Region 4 Sample Coordinator (Direct: 706-355-8839, Cell: 706-340-2145, hendel.jeffrey@epa.gov) to arrange for sample receipt.

- Region 7 (metals analysis, prior to March 2016)

  Samples Receiving / Nicole Roblez
  U.S. EPA - Region 7 ENST/LTAB
  300 Minnesota Ave.

Kansas City, KS 66101

Before shipping samples to Region 7, please notify the Region 7 Sample Coordinator (913-551-5130, roblez.nicole@epa.gov) to arrange for sample receipt.

- Region 10 (metals analysis, as needed)

  Samples Receiving / Gerald Dodo
  U.S. EPA Region 10 Laboratory
  7411 Beach Dr. East
  Port Orchard, WA 98366

  Before shipping samples to Region 10, please notify the Region 10 Sample Coordinator (360-871-8728, Dodo.Gerald@epa.gov) to arrange for sample receipt.

- PHILIS Contract Laboratory (metals analysis for selected Faucet Filter Evaluation samples [see Section 5.1], metals analysis for Aerator Particulate samples [see Section 5.5], TTHM and HAA9 analysis for Distribution System samples [see Section 5.2], and various analyses for Health and Direct Contact Exposure Evaluation samples [see Section 5.4])

  PHILIS CSS-Dynamac
  c/o EPA Region 2
  2890 Woodbridge Ave, Bldg 238
  Edison, NJ 08837

  Before shipping samples to the PHILIS Contract Laboratory, please notify the sample coordinator contact (Sang Chung, 219-477-8860) to arrange for sample receipt.

Appendix J-4 – Reporting Limits and Detection Limits for EPA and Contract Laboratories

Analyte	Analytical Method	Sample Matrix	MDL - CRL	Reporting Limit - CRL	MDL - R1	Reporting Limit - R1	MDL - R4	Reporting Limit - R4	MDL - R7	Reporting Limit - R7	MDL - R10	Reporting Limit - R10	MDL - Test America	Reporting Limit - TestAmerica	Units	Hold Time	Bottle Type	Preservative
Metals - Standard List																		
Total Lead			0.014	0.500		0.20	0.038	0.50	0.35	1.0	0.019	0.50	0.110	0.50	µg/L			
Total Copper			0.140	1.00		0.20	4.1	10	0.66	2.0	0.16	1.0	0.750	5.00	µg/L			
Total Zinc			1.20	10.0		5.0	1.1	10		2.0	0.54	5.0	7.30	50.0	µg/L			
Total Aluminum			0.0270	0.200		0.110	0.017	0.10		0.050	0.0087	0.20	0.00900	0.200	mg/L			
Total Iron			0.0160	0.0800		0.040	0.010	0.10		0.050	0.0030	0.080	0.0160	0.100	mg/L			
Total Calcium			0.0210	0.200		0.100	0.025	0.25	0.07	2.0	0.0053	0.20	0.240	5.00	mg/L			
Total Cadmium			0.000210	0.00200			0.000066	0.00050		0.0010	0.00018	0.0020	0.0000610	0.00200	mg/L			
Total Potassium			0.0720	0.800		1.00	0.083	1.0	0.12	2.0	0.023	0.80	0.0300	5.00	mg/L			
Total Magnesium			0.0220	0.200		0.100	0.025	0.25	0.05	2.0	0.0038	0.20	0.0480	5.00	mg/L			
Total Manganese			0.00160	0.00800		0.020	0.00050	0.0050		0.005	0.00025	0.0080	0.00110	0.0150	mg/L			
Total Sodium			0.0360	0.400		1.00	0.10	1.0	0.02	5.0	0.0063	0.40	0.0680	5.00	mg/L			
Total Nickel	Based on EPA 200.7/ 200.8	Drinking Water	0.00180	0.00600		0.020	0.000046	0.0010		0.0010	0.00036	0.0060	0.00023	0.0400	mg/L	6 months	HDPE – 125mL or 1,000-mL	HNO_3 to pH<2
Total Tin			0.00410	0.0200		0.020	0.0015	0.015	NA	NA	0.0016	0.020	0.0013	0.10	mg/L			
Total Chromium			0.000860	0.00500		0.020	0.0011	0.0050		0.0020	0.00048	0.0050	0.000200	0.00500	mg/L			
Additional Metals - Full List																		
Total Antimony			0.000069	0.0010	NA	NA	0.000033	0.0010	NA	NA	NA	NA	0.00016	0.010	mg/L			
Total Arsenic			0.00015	0.0010	NA	NA	0.00064	0.0010	NA	NA	NA	NA	0.00018	0.010	mg/L			
Total Barium			0.00042	0.00300	NA	NA	0.00083	0.0050	NA	NA	NA	NA	0.0011	0.20	mg/L			
Total Beryllium			0.000210	0.00200	NA	NA	0.00018	0.0030	NA	NA	NA	NA	0.000053	0.0050	mg/L			
Total Boron			0.00470	0.0500	NA	NA	0.0050	0.050	NA	NA	NA	NA	0.011	0.20	mg/L			
Total Molybdenum			0.00160	0.0120	NA	NA	0.00041	0.010	NA	NA	NA	NA	0.00023	0.040	mg/L			
Total Selenium			0.0370	0.0500	NA	NA	0.00046	0.0020	NA	NA	NA	NA	0.00025	0.0050	mg/L			
Total Silver			0.00097	0.0100	NA	NA	0.00060	0.0050	NA	NA	NA	NA	0.000020	0.0050	mg/L			
Total Thallium			0.000050	0.00050	NA	NA	0.000091	0.0010	NA	NA	NA	NA	0.000074	0.0100	mg/L			
Total Vanadium			0.00025	0.0010	NA	NA	0.0019	0.0050	NA	NA	NA	NA	0.00023	0.0070	mg/L			
Total Phosphorus	Based on EPA 365.4	Drinking Water	0.06	0.15	Not applicable		Not applicable		Not applicable		Not applicable		Not applicable		mg/L	28 days	HDPE – 125mL	H2SO4 to pH<2, Cool <6C
Total Alkalinity (as $CaCO_3$)	Based on EPA 310.1	Drinking Water	5.0	20	Not applicable		Not applicable		Not applicable		Not applicable		1.9	5.0	mg/L	14 days	HDPE – 125mL	Cool <6C
Water Quality Anions																		
Sulfate (as SO4)	Based on EPA 300.0	Drinking Water	0.02	0.12	Not applicable		Not applicable		Not applicable		Not applicable		0.13	1.0	mg/L	28 days	HDPE – 125mL	Cool <6C
Chloride			0.03	0.12									0.41	1.0	mg/L			
Fluoride			0.01	0.02									0.009	1.0	mg/L			
TTHMs	EPA 524.2	Drinking Water	In accordance with PHILIS Contract Laboratory SOPs.													14 days	Three 40-mL VOAs	Cool <6C, Sodium Thiosulfate, no headspace
HAA9	EPA 552.3	Drinking Water	In accordance with PHILIS Contract Laboratory SOPs.													14 days (21 days for extract)	One 250-mL amber glass	Cool <6C, Ammonium Chloride
TDS	Based on Standard Method 2540C	Drinking Water	20.0	20.0	Not applicable		Not applicable		Not applicable		Not applicable		7.4	10	mg/L	7 days	HDPE – 125mL	Cool <6C
Turbidity	Based on EPA 180.1	Drinking Water	0.12	0.5	Not applicable		Not applicable		Not applicable		Not applicable		Not applicable		NTU	48 hours	HDPE – 125mL	Cool, <6C
Hardness, Calculated (as $CaCO_3$)	Based on Standard Method 2340B	Drinking Water	0.11	1.32	Not applicable		Not applicable		Not applicable		Not applicable		Not applicable		mg/L	6 months	N/A – metals bottle(s)	HNO3 to pH<2

Notes:

Region 7 (R7) reports estimated detections of lead, copper, calcium, magnesium, potassium, and sodium down to the MDL (with J qualifiers) to allow quantification to similar levels as CRL.

TestAmerica reports estimated detections of lead and other metals down to the MDL (with J qualifiers) to allow quantification to similar levels as CRL.

Method Detection Limits - The MDLs will be re-determined before the samples are analyzed per the EPA or contract laboratory's Quality Management Plan which requires MDL studies to be performed yearly.