VERIFICATION TEST PLAN
FOR
THE DENTAL RECYCLING NORTH AMERICA
MERCURY REMOVAL SYSTEM

Prepared for
NSF International
Ann Arbor, Michigan
and
The Environmental Technology Verification Program
of the
US Environmental Protection Agency
Edison, New Jersey

by

Scherger Associates
Huntersville, North Carolina

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EXECUTIVE SUMMARY

This Verification Test Plan (VTP) describes the procedures that will be used to test the mercury and mercury amalgam removal performance of the Dental Recycling North America, Inc. (DRNA) Mercury Removal Unit (MRU) when used in a general dentistry practice. DRNA sells a MRU unit that is designed to remove particulate and soluble mercury that is present in the discharge from dental office vacuum systems. The MRU includes a mercury amalgam separator unit that is based on sedimentation theory for removal of particulate and an adsorbent system that removes soluble mercury by adsorption onto a solid media.

An initial characterization test to determine the mercury levels in untreated wastewater from the vacuum system will be performed by collecting 25 samples representing 25 days of operation at the dental office. The verification test period will include the collection of 25 samples collected over 25 days of operation and will include analysis of the treated water for settleable, soluble and insoluble mercury. Residuals from the separator unit, the particle filter, and adsorbent filter will be collected and analyzed at the end of the verification test.

The dental office selected as the test site operates five dental chairs with two dedicated to hygiene activities. This is a general dentistry practice that is representative of a small dental office. The standard DRNA MRU is designed for this type of application.

The Test Organization (TO) for this verification test is a consortium comprised of NSF International's laboratory and QA/QC groups, Adam Markie, a field support person familiar with the DRNA MRU unit, and Scherger Associates, who will handle plan development, data management and report writing. The NSF laboratory is experienced in a wide range of environmental analysis including the mercury procedures approved by EPA. The laboratory will perform all of the special sample handling, including the solids separation, volume measurements, and soluble and insoluble mercury analysis. TCLP analysis will be subcontracted to Trimatrix Laboratory, an experienced solid waste and environmental testing organization.

This Verification Test Plan was prepared based on information provided by DRNA and the NSF laboratory and is based on the ETV document, "Protocol for the Verification of Mercury Amalgam Removal Technologies."

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GLOSSARY

Accuracy - a measure of the closeness of an individual measurement or the average of a number of measurements to the true value and includes random error and systematic error.

Bias - the systematic or persistent distortion of a measurement process that causes errors in one direction.

Commissioning – the installation of the mercury amalgam removal technology (free of mercury residuals) and start-up of the technology using test site wastewater.

Comparability – a qualitative term that expresses confidence that two data sets can contribute to a common analysis and interpolation.

Completeness – a qualitative term that expresses confidence that all necessary data have been included.

Mercury Free Water – laboratory prepared water used in analysis and cleaning procedures that is tested to ensure the mercury concentration in the water is <0.2 ug/L of mercury.

Mercury, Settleable – total mercury measured in the settled residue from the wastewater sample after settling the wastewater for eight to sixteen hours in accordance with the SOP for sampling handling and settling.

Mercury, Soluble – mercury measured in the filtrate from a liquid sample that has been filtered through a 0.45-micron filter.

Mercury, Total – mercury measured in a liquid sample that has not been filtered. The entire sample, including liquid and any particulate present, is used for the analysis.

Owner – the owner of a dental office used as a test site for verification testing.

Precision - a measure of the agreement between replicate measurements of the same property made under similar conditions.

Protocol – a written document that clearly states the objectives, goals, scope and procedures for the study. A protocol shall be used for reference during Vendor participation in the verification testing program.

Quality Assurance Project Plan – a written document that describes the implementation of quality assurance and quality control activities during the life cycle of the project.

Residuals – the waste streams, excluding final effluent, which are retained by or discharged from the technology.

Representativeness - a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point, a process condition, or environmental condition.

Source Water Protection Stakeholder Advisory Group - a group of individuals consisting of any or all of the following: buyers and users of mercury amalgam removal and other technologies, developers and vendors, consulting engineers, the finance and export communities, and permit writers and regulators.

Standard Operating Procedure – a written document containing specific procedures and protocols to ensure that quality assurance requirements are maintained.

Surfaces - refers to the surface of a tooth, there are six possible surfaces per tooth, top, four sides, and bottom

Technology Panel - a group of individuals with expertise and knowledge in mercury amalgam removal technologies.

Testing Organization – an independent organization qualified by the Verification Organization to conduct studies and testing of mercury amalgam removal technologies in accordance with protocols and test plans.

Vendor – a business that assembles or sells mercury amalgam removal equipment.

Verification – to establish evidence on the performance of mercury amalgam removal technologies under specific conditions, following a predetermined study protocol(s) and test plan(s).

Verification Organization – an organization qualified by USEPA to verify environmental technologies and to issue Verification Statements and Verification Reports.

Verification Report – a written document containing all raw and analyzed data, all QA/QC data sheets, descriptions of all collected data, a detailed description of all procedures and methods used in the verification testing, and all QA/QC results. The Test Plan(s) shall be included as part of this document.

Verification Statement – a document that summarizes the Verification Report reviewed and approved by USEPA.

Verification Test Plan – A written document prepared to describe the procedures for conducting a test or study according to the verification protocol requirements for the application of mercury amalgam removal equipment at a particular test site. At a minimum, the Test Plan shall include detailed instructions for sample and data collection, sample handling and preservation, precision, accuracy, goals, and quality assurance and quality control requirements relevant to the particular dental office test site.

ABBREVIATIONS AND ACRONYMS

ANSI	American National Standards Institute
ASQC	American Society for Quality Control
DRNA	Dental Recycling North America, Inc.
DQI	data quality indicators
DQO	data quality objectives
ETV	Environnemental Technologies Vérification
MSDS	material safety data sheets
MRU	Mercury Removal Unit
NSF	NSF International
NRMRL	National Risk Management Research Laboratory
O&M	operational and maintenance
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
QMP	quality management plan
SOP	standard operating procedure
TCLP	toxicity characteristic leaching procedure
TO	Test Organization
USEPA	United States Environmental Protection Agency
VTP	Verification Test Plan

1.0 INTRODUCTION

This document contains the technology specific Verification Test Plan (VTP) to be used for the verification testing of the Dental Recycling North America, Inc. (DRNA) mercury amalgam removal system (MRU) used for the removal of mercury in wastewater from dental offices. The DRNA Mercury Removal Unit (MRU) to be evaluated includes two processing units, the BullfroHg air/water/amalgam separator and the mercury adsorbent filter. This Verification Test Plan has been prepared in accordance with the Protocol for the Verification of Mercury Amalgam Removal Technologies (April 2001) developed under the United States Environmental Protection Agency (USEPA) Environmental Technologies Verification (ETV) program's Source Water Protection Pilot.

The ETV Program USEPA is intended to:

- Evaluate the performance of innovative and commercially available environmental technologies;
- Provide permit writers, buyers and users, among others, with objective information about technology performance; and,
- Facilitate "real world" implementation of promising technologies.

The ETV program has developed verification testing protocols that are intended to serve as templates for conducting verification tests for various technologies. The Protocol for the Verification of Mercury Amalgam Removal Technologies was published as the guidance document for test plan development for verification testing of mercury amalgam treatment systems. This VTP was developed in accordance with this guidance document. The goal of the verification testing process is to generate high quality data for verification of equipment performance.

The ETV Program is subdivided into twelve individual pilot projects, one of which is the Source Water Protection Pilot. This Pilot includes the verification testing of mercury amalgam removal technologies appropriate for the removal of mercury from wastewater produced by dental practices.

NSF International oversees the verification testing pilot project for mercury amalgam removal technologies under the sponsorship of the USEPA Urban Watershed Branch, Water Supply and Resources Division. The role of NSF is to provide technical and administrative leadership in conducting the testing.

It is important to note that verification of the equipment does not mean that the equipment is "certified" or "approved" by NSF or USEPA. Instead, the verification testing pilot projects are a formal mechanism by which the performance of equipment can be determined by these two Agencies, and which can result in the issuance of a Verification Statement by NSF and USEPA.

2.0 OBJECTIVES AND DESCRIPTION OF THE VERIFICATION TESTING

2.1 OBJECTIVES

Dental Recycling North America, Inc. manufactures mercury amalgam removal devices that are designed to reduce the mercury that is present in wastewater from dental offices. The individual units are designed to operate alone or in combination to reduce the quantity of mercury discharged from a dental office. The treatment unit that will be tested in this verification is the DRNA Mercury Removal Unit (MRU).

Verification testing of mercury amalgam treatment systems under the ETV Source Water Protection Pilot for Mercury Amalgam Removal Technologies is designed to verify mercury removal performance of systems that can be used in dental offices. The primary objective of the ETV is to measure the performance of these technologies for the removal of mercury in real world applications through a well-defined test plan that includes measurement of mercury (insoluble and soluble) in the wastewater before and after application of the treatment technology.

The objective of this VTP is to determine the total mercury reduction that is attained by the Dental Recycling North America Mercury Removal Unit (MRU) when used to treat the effluent from a dental office. Reduction of insoluble and soluble mercury will be evaluated to determine the effectiveness of the system to remove both types of mercury present in the wastewater.

The objective will be achieved by implementing testing procedures presented in this Verification Test Plan. An initial characterization period will include collection of samples of untreated wastewater for a 25 business day period. The samples will be analyzed for settleable mercury, and for soluble and insoluble mercury in the decanted supernatant. The treatment technology will then be operated for 25 business days with samples of the treated wastewater being collected on a daily basis. These samples will be analyzed for settleable mercury, and for soluble and insoluble mercury in the decanted supernatant.

The treatment system will also be monitored for operation and maintenance characteristics, including the performance and reliability of the equipment and the level of operator maintenance required. Data will be collected on any chemical usage, energy issues, and the generation of residues. At the end of the test period, solids accumulated in the DRNA MRU will be collected and tested. The adsorbent will be tested for mercury content.

The DRNA literature claims that the MRU removes anywhere from 95% to 99% of the mercury that would otherwise exit the doctor’s office and that the mercury is captured in the system and retained for recycling. The only mercury leaving the separator is soluble mercury and a small amount of very fine powdery particulate. DRNA claims that the mercury adsorbent filter when installed downstream of the Separator will remove mercury in solution to achieve “zero detect”

or no detectable mercury in the effluent. (Author's note: The typical method detection limit for mercury in water and wastewater is <0.2 ug/L).

2.2 TEST SITE DESCRIPTION

The office is a general practice dental office that operates four (4) days per week. The office has five chairs with two chairs being used for dental hygiene work and three chairs for general dentistry procedures. The office currently averages approximately 24 amalgam removals per four-day week and 12 amalgam placements per 4-day week. The average number of surfaces represented by these procedures is 72 surfaces (48 surfaces out; 24 surfaces in). The DRNA MRU is designed for dental offices with up to six (6) operatories (chairs). Larger clinics are required to contact DRNA to obtain information on the proper sizing for the unit.

The vacuum collection system at the facility is a dry type system. Each chair unit has a coarse chair side trap (Pinnacle DisposaTrap, Model 5501, 20 mesh size) that protects the vacuum system from very large particles entering the piping and clogging the system. The individual chair locations are piped to a common vacuum header that runs to the utility room where the vacuumed pump is located. There is an air/water separator located just ahead of the vacuum pump, which collects all the wastewater from the chairs. There is no commingling of any other waste in this part of the system. In normal operation the air/water separator collects all of the wastewater generated during the day. At the end of the day when the system is shutoff, the collection container empties automatically and the wastewater flows into the sanitary sewage system for the building through an inlet drain.

The current practice at this office is to replace the coarse chair side traps once every four days (once per operating week). The material from the chair side traps is placed in a special container and then sent out for recovery/reclaim of the mercury. This basic procedure will continue to be followed throughout the test period, except that the trap material will be taken to the laboratory and weighed prior to being sent for reclamation.

Another current practice at this office is to flush each of the chair side units every fourth business day with Pure-Vac cleaning solution (MSDS sheet in Appendix D). Pure-Vac is an inorganic/organic mixture cleaning solution that is one of the solutions recommended by DRNA for use with their treatment system (contains phosphoric acid, glycolic acid, and isopropyl alcohol). Line flushing is performed to maintain the vacuum system and cleanout any build-up of material in the lines to the vacuum pump. The volume of solution for each chair is approximately 500 ml. A total of 2.5 liters of solution is typically used to clean the entire system of five chairs. This procedure will continue during the entire test period, as it is a typical practice in dental offices.

2.3 WASTEWATER CHARACTERISTICS

There is no historical data available on the wastewater flow or mercury content from this facility. The facility is, however, typical of a normal general dentistry practice and the wastewater can be

expected to be typical of a general dentistry office. Water was collected for one typical operating day and the volume produced for the entire day was approximately 2-3 liters (½ to ¾ gallons). This was accomplished to help size the container to be used for the characterization study. The container is sized to collect all of the flow from a day of activity. Based on this information and the flushing activity, a 10-liter sample container should provide adequate safety margin to insure all of the flow from a 24-hour period is collected without overflowing the container.

Given the lack of background analytical data for the system, a full Initial Characterization will be performed as part of this VTP. This initial characterization has been incorporated into the VTP so that the procedures will be well documented and so that all QA/QC procedures for sample collection and analysis will be consistent. This is a slight deviation from the ETV Protocol, which calls for the characterization results to be included in the VTP document. In this case, it is believed that incorporating the characterization procedures and requirements into the actual VTP is appropriate and will provide a consistent set of results for comparison with the verification test results. Samples of untreated wastewater will be collected for a period of 25 business days as recommended in the Verification Protocol.

2.4 TECHNOLOGY INSTALLATION AND PROCEDURES

A DRNA MRU is currently installed at the site and has been operational for a few months. The current MRU is installed after the air/water separator. The BullfroHg separator, part of the MRU, is located on the floor below the vacuum system air/water separator. The inlet to the BullfroHg is connected by vacuum hose to the drain on the bottom of the air/water separator. A valve in this line is opened automatically when the vacuum is shut down at the end of the day. This allows the wastewater collected during the entire day's activities to flow into the settling unit. The wastewater then remains in this part of the MRU while particulates settle to the bottom of the unit. Tubing connects the outlet port of the BullfroHg separator to a small pump, which is used to pump the settled effluent through the adsorbent filter unit. The pump is activated daily at a preset time and the settled wastewater is pumped through the adsorbent column. The effluent from the adsorbent filter is discharged to a drain via the utility sink located immediately adjacent to the unit. The current MRU will remain in place during the characterization test, as it is located downstream of the normal vacuum system plumbing and does not impact the normal wastewater flow. The MRU should receive no flow during the characterization test because the entire flow will be collected upstream in the sample container. As described below, the current installation is not in accordance with the manufactures recommendation. The MRU is designed to be placed before the normal system air/water separator. Characterization samples and MRU verification will be done at the sampling location before the air/water separator which will match the vendor recommended installation and operation for the MRU.

This system contains a chair side DRNA Particle Trap at each dental chair. The Particle Trap units will be disconnected and by-passed during the characterization test and verification test periods. The vacuum line will run directly from the chair through a standard coarse chair side trap and then to the main header. The sample collection container will be located in the main header just before the air/water separator and the vacuum pump. Following completion of the

entire characterization and verification test program, the Particle Traps will be re-connected at each chair location. The Particle Trap is not part of this verification test.

Figure 2-1 shows the current configuration of the dry vacuum system at the dental office.

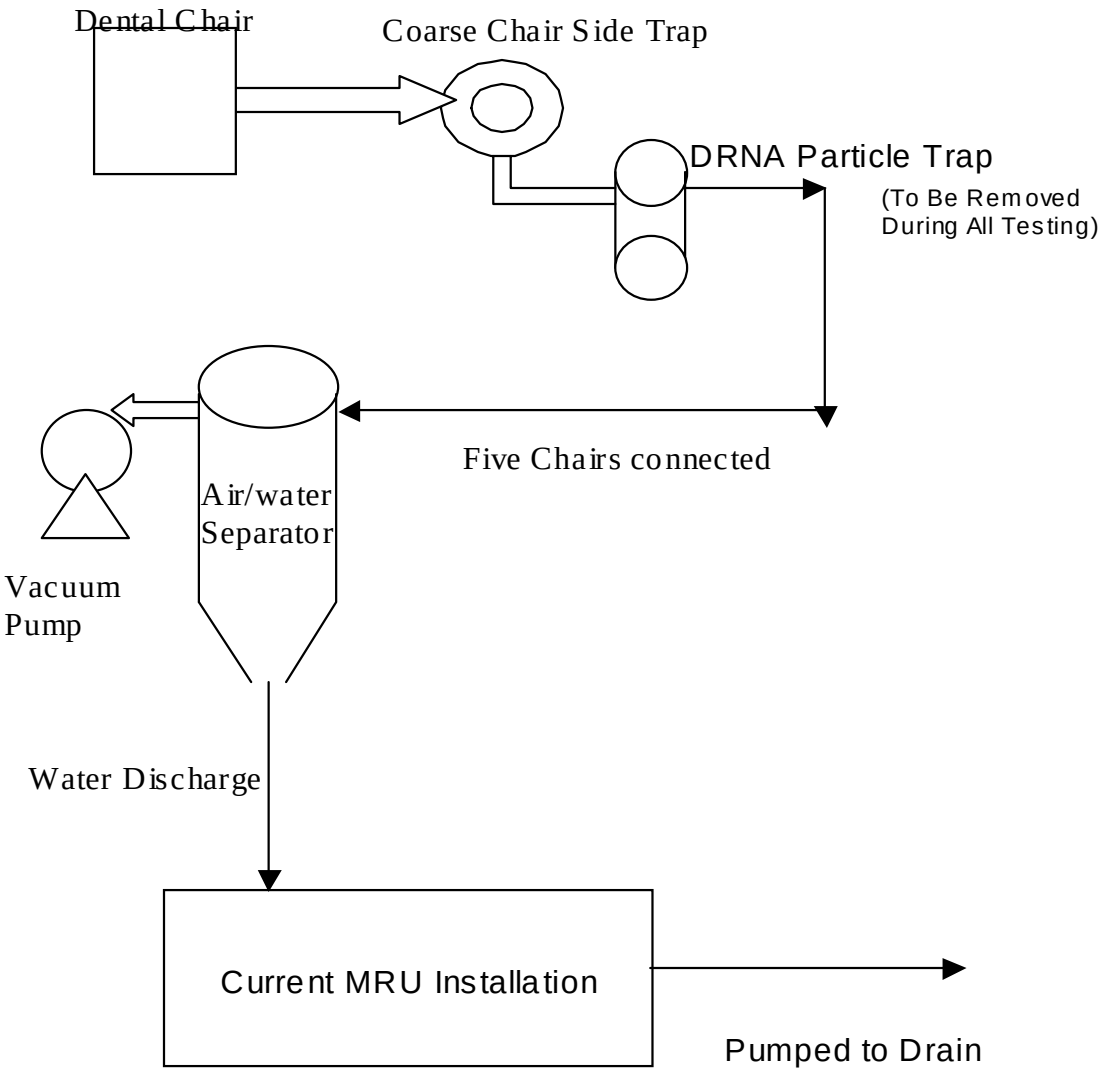


FIGURE 2-1: Current Vacuum System and MRU Installation

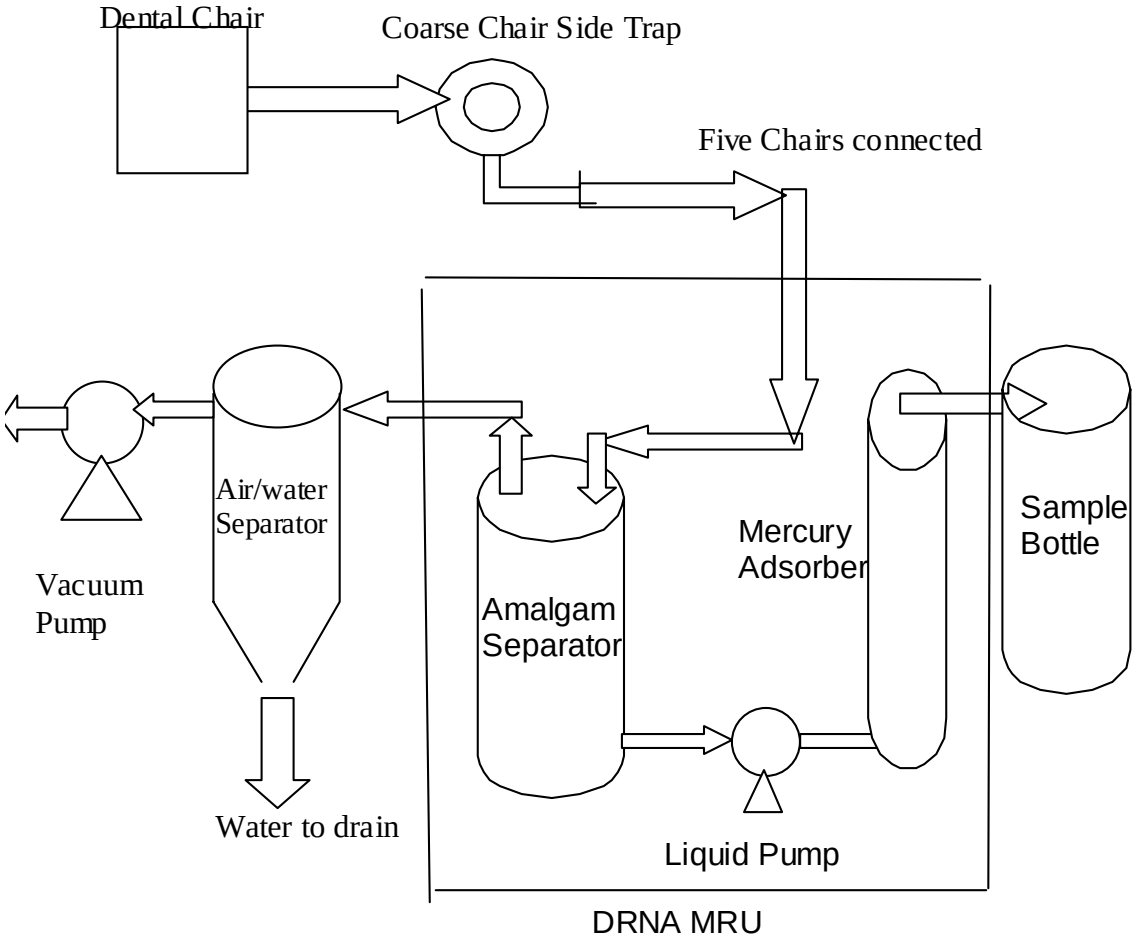


Figure 2-2: Schematic Diagram of the DRNA MRU System Installation

A sample bottle collection system will be installed for collecting samples during the Initial Characterization Study. The requirement for the protocol is to collect the entire flow from a 24-hour period of operation that will then be used to characterize the wastewater. Collection of the entire flow eliminates the concern about obtaining unrepresentative samples that may contain large chunks of solids and eliminates the need to consider flow weighted composite samples versus time composite samples. A 10-liter vacuum-rated polypropylene container will be used for the sample collection container. The container will be plumbed into the vacuum system just prior to the current air/water separator vessel. The collection container will be set up to maintain the vacuum in the system. The elevation of the container inlet will be at approximately the same height as the current inlet to the air/water separator, which is approximately three (3) feet above the floor. Thus, the water being collected in the sample container will be the same water that is normally collected in the air/water separator. The sample container will be changed daily and a clean sample container installed.

Figure 2-3 shows a schematic diagram of the sample bottle and collection system installation.

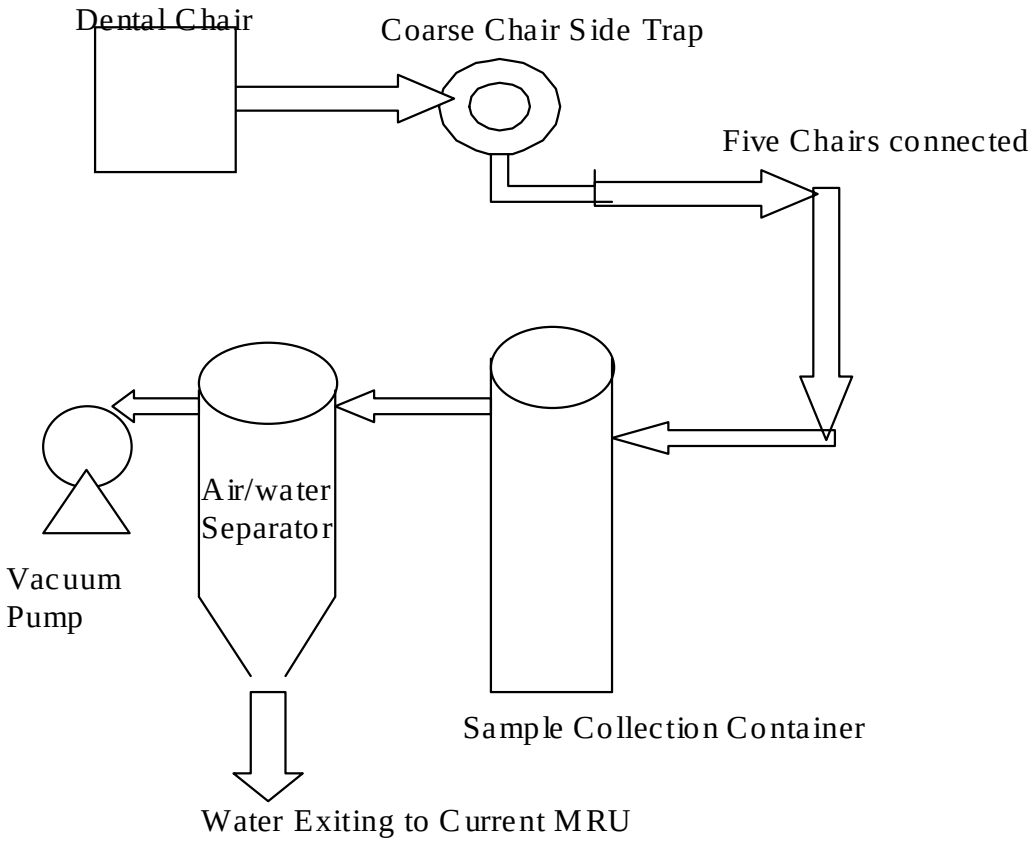


Figure 2-3: Sample Bottle and Collection System Schematic

At the end of the characterization test and prior to beginning the verification test, the entire MRU will be replaced with a new system. The new MRU system will be installed in the vacuum line upstream of the existing air/water separator, as recommended by DRNA. The inlet to the MRU will be connected at the same location as the sample collection container used during the characterization study. As specified in the installation manual, the wastewater will be collected prior to the air/water separator. The air/water separator will remain in-line downstream of the MRU settling unit as a protection for the vacuum pump in the case the settling unit should overflow. The treated effluent from the adsorbent filter will be directed into a 10-liter polypropylene container that will collect all of the effluent from a twenty-four hour period of dental office operation. The sample bottle will be located at the utility sink so that in the case of an overflow the treated water will discharge to the sink and the sewer system. As in the case of the characterization sample collection, all of the wastewater generated and treated will be collected as a sample. This approach eliminates the need to composite or sub sample the treated water. Figure 2-4 shows a schematic diagram of the DRNA system installation.

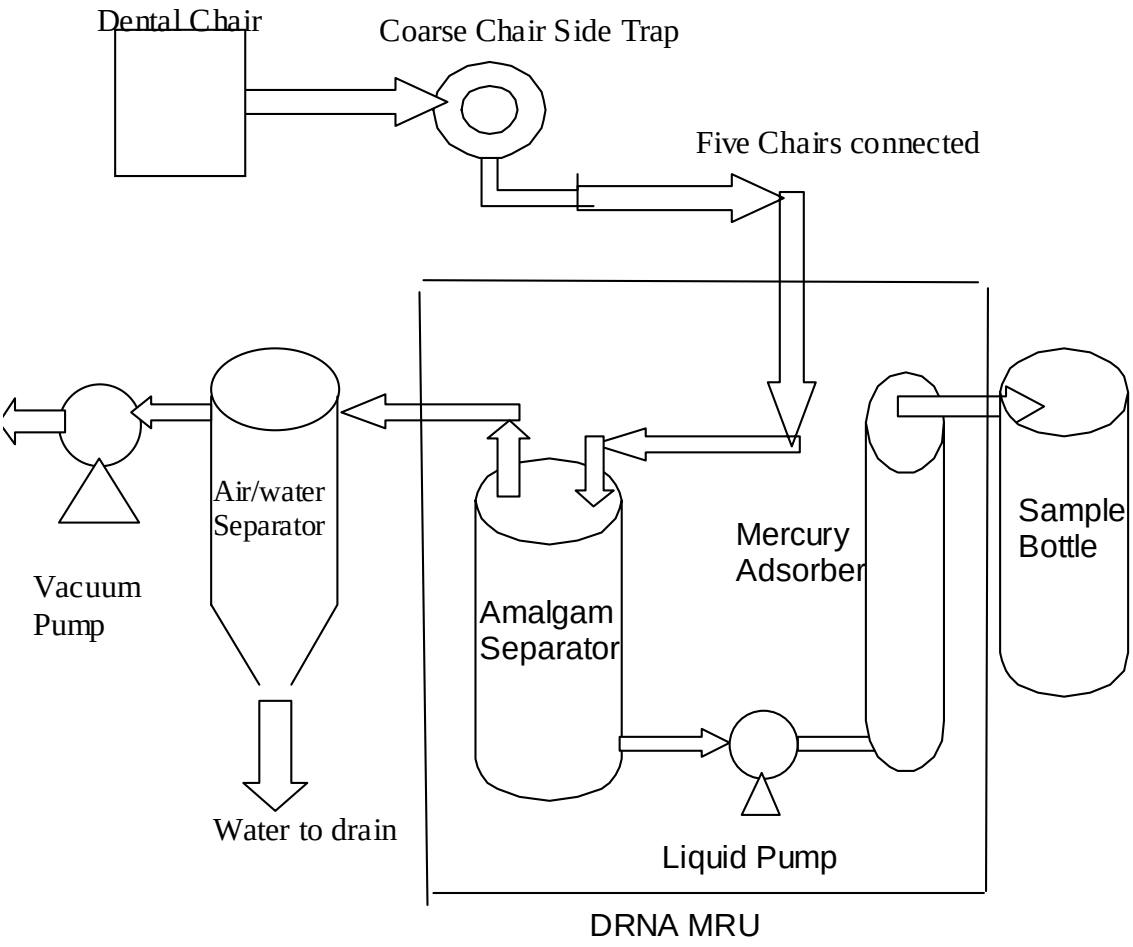


Figure 2-4: Schematic Diagram of the DRNA MRU System Installation

2.5 HANDLING EFFLUENT AND RESIDUES

All of the wastewater effluent, either treated or not treated, will be collected as sample for delivery to the laboratory. Therefore, during the characterization test period and the verification test period no effluent will be discharged from the dental office to the sewer system. The laboratory will receive the samples for analysis. When the analytical work is complete, the laboratory will dispose of any remaining wastewater in accordance with the standard laboratory practice for wastewater sample disposal.

There will be no residues generated at the dental office during the characterization work, except for the chair side traps, as all of the wastewater will be collected for analysis. The chair side traps will be changed on a weekly basis, per the standard operating procedure, and the residue from these traps will be placed in a special trap container that is normally used to ship the trap material to a mercury recycle company. In this case, the chair side trap material will sent to the laboratory to be weighed prior to being shipped to DRNA for recycle. Any residues from the characterization samples not consumed in the analytical procedures or sent to DNRA for recycling will be handled in accordance with standard laboratory procedures for disposal of solid residues.

Solid material will be removed by the DRNA MRU in the settling unit (BullfroHg), during the verification tests. These solids will accumulate in the unit until the end of the verification test. The separator, particle filter and adsorbent filter will be removed from the MRU and sent to the laboratory. The laboratory will open the individual units and remove the residues for analysis. Any residues from the verification samples not consumed in the analytical procedures will be handled in accordance with standard laboratory procedures for disposal of solid residues or will be sent to DRNA for recycling as part of their normal procedures for handling residues and adsorbent. The chair side traps will be changed on a weekly basis during the verification test, per the standard operating procedure, and the residue from these traps will be placed in a special trap container that is normally used to ship the trap material to a mercury recycle company. In this case the chair side trap material will sent to the laboratory to be weighed prior to being shipped to DRNA for recycle.

2.6 TIME SCHEDULE

It is expected that the schedule for influent characterization testing, system installation, and verification testing will follow the time line given below. The dental office normally operates only four days per week. Therefore, in order to collect the twenty five samples called for in the ETV Protocol (daily samples for five weeks), the actual sample collection for characterization and verification tests, will span two - 25 business day periods, which corresponds to 6 weeks and one day per test period.

WEEKLY SCHEDULE SUMMARY

Week One -	Install characterization sample collection container in vacuum system Disconnect and by-pass the DRNA Particle Traps at each chair Test the collection system
Week Two	Begin characterization sample collection - 4 days of sampling
Weeks Three Seven	Continue collecting characterization samples 4 days/week for 5 weeks = 20 samples
Week Eight	At the end of the last sample day- flush the system with flushing solution using the normal protocol Collect last characterization sample – 1 sample Review the characterization data to insure that the dental system and the record keeping meet the objectives and needs of the verification test. Obtain approval for the Verification Organization, NSF to proceed with the verification test.
Week Nine	Once approval to proceed with the verification in obtain begin to install a new DRNA MRU unit in the vacuum system. (Note: if approval to proceed is obtained at the beginning of Week Eight, installation can proceed earlier.) Place discharge tube from the MRU into a sample bottle and test the system. Run the entire system with clean water for a period of time to verify all is working correctly. The flush water collected in the sample bottle will be sent to the laboratory as a normal sample for mercury analysis. (Verification sampling may be able to begin this week if the MRU is installed, checked and ready for operation, and the characterization review by the VO is complete.)
Week Ten	Begin Verification Testing – Collect daily samples for 4 operating days
Week Eleven To Fifteen	Continue collecting characterization samples 4 days/week for 5 weeks = 20 samples
Week Sixteen	At the end of the last operating day, thoroughly flush the system with flushing solution. Collect last verification test sample – 1 sample

	Remove the BullfroHg settling container from the MRU system and send to the laboratory for residue removal. Remove the particle filter and adsorbent filter units and send to the laboratory for analysis of residues and the adsorbent. The particle filter and adsorbent will be analyzed separately. Restore all parts of the vacuum system to the original condition prior to the test. Install new MRU parts (BullfroHg, particle filter and adsorbent filter) and re-install the DRNA Particle Traps at each chair location.
Weeks Seventeen To Nineteen	Complete the laboratory analysis of all samples.

3.0 VERIFICATION TESTING RESPONSIBILITES

EPA sponsors the ETV Program and the program is implemented through contracted Verification Organizations (VO). NSF International is the VO for the Source Water Protection ETV Pilot. The VO is responsible for selection of the Testing Organization for each technology to be verified and to provide oversight for the testing program. NSF reviews all test plans and oversees all of the participants in the testing program to ensure there is no bias or conflict of interest that could influence the test results. The Testing Organization for this verification includes team members from the NSF laboratory and QA/QC group, as well as field personnel associated with the vendor DRNA. The NSF VO team will be separate from these team members and will provide independent review and oversight using staff and managers not involved in the day to day Testing Organization work.

3.1 NSF INTERNATIONAL - VERIFICATION ORGANIZATION

The Source Water Protection ETV Pilot is administered through a cooperative agreement between USEPA and NSF International, Inc. (NSF) its verification partner organization for the Source Water Protection Technologies Pilot. NSF administers the Pilot, and has organized the Testing Organization, a consortium of companies to develop and implement this Verification Test Plan (VTP).

NSF's responsibilities as the Verification Organization include:

- Review and comment on the site specific Test Plan;
- Coordinate with peer-reviewers to review and comment on the Test Plan;
- Coordinate with the EPA Pilot Manager and the technology vendor to approve the Test Plan prior to the initiation of verification testing;
- Review the quality systems of all parties involved with the Testing Organization and subsequently, qualify the companies making up the Testing Organization;
- Oversee the technology evaluation and associated laboratory testing;
- Carry out an on-site audit of test procedures;
- Oversee the development of a verification report and verification statement;
- Coordinate with EPA to approve the verification report and verification statement;
- Provide QA/QC Review and Support for the TO

Key contacts at NSF for the Verification Test Plan and Program are:

Mr. Thomas Stevens, Program Manager
(734) 769-5347 email: Stevenst@NSF.org

Ms. Maren Roush, Project Coordinator, Verification Organization (VO)
(734) 827-6821 email: MRoush@NSF.org

NSF International
789 Dixboro Road
Ann Arbor, Michigan 48105
(734) 769-8010

3.2 U.S. ENVIRONMENTAL PROTECTION AGENCY

The USEPA Office of Research and Development through the Urban Watershed Branch, Water Supply and Water Resources Division, National Risk Management Research Laboratory (NRMRL) provides administrative, technical, and quality assurance guidance and oversight on all ETV Source Water Protection pilot activities. The USEPA will review and approve each phase of the verification project. The USEPA's responsibilities will include:

- Verification Test Plan review and approval;
- Verification Report review and approval; and
- Verification Statement review and approval.

The key USEPA contact for this program is:

Mr. Ray Frederick, Project Officer, ETV Source Water Protection Pilot
(732)-321-6627 email: Frederick.ray@epa.gov

U.S. EPA, NRMRL
Water Supply and Water Resources Division
2890 Woodbridge Ave. (MS-104)
Edison, NJ 08837-3679

3.3 TESTING ORGANIZATION

The Testing Organization (TO) for the verification testing is a consortium of NSF International, Inc., Scherger Associates, and Mr. Adam Markie. This group was organized by NSF to bring together resources that can complete a high quality verification test program in a cost effective manner. Each participant in the consortium has a well-defined role in planning and executing the VTP.

Mr. Dale Scherger of Scherger Associates will be the Project Manager (TO) for the TO and will be responsible for coordination and development of this VTP, obtaining all of the information needed to plan and execute the VTP, managing the data collected during the test period, preparing the draft final report, and providing technical guidance in conjunction with the Technology Panel. Mr. Adam Markie will provide field support at the test site, including setup and operation of the MRU, collection of the daily and weekly records from the dental office, and collection and shipment of the samples on a daily basis. Mr. Markie will provide any maintenance support required during the verification test period in consultation with the vendor, DRNA.

NSF International will provide the laboratory services for the testing program and will provide consultation and implementation on any sampling and analytical issues that need to be addressed throughout the verification test period. NSF will be responsible for all quality assurance for the VTP through its QA group. NSF will provide administrative and technical support for review and production of the VTP and the Final Report. NSF will also handle project management and cost tracking support for this VTP. The NSF staff involved in the VTP as members of the TO will be separate from the NSF management and staff that are providing the oversight for the ETV program as members of the VO.

The responsibilities of the TO consortium include:

- Preparation of the site specific Verification Test Plan;
- Conducting Verification Testing, according to the Verification Test Plan;
- Installation, operation, and maintenance of the MRU in accordance with the Vendor's O&M manual(s);
- Controlling access to the area where verification testing is being carried out;
- Maintaining safe conditions at the test site for the health and safety of all personnel involved with verification testing;
- Scheduling and coordinating all the activities of all verification testing participants, including establishing a communication network and providing logistical and technical support on an "as needed" basis;
- Resolve any quality concerns that may be encountered and report all findings to the Verification Organization;
- Managing, evaluating, interpreting and reporting on data generated by verification testing;
- Evaluation and reporting on the performance of the technology; and,
- If necessary, document changes in plans for testing and analysis, and notify the Verification Organization of any and all such changes before changes are executed.

The key personnel and contacts for the TO are:

SCHERGER ASSOCIATES

Mr. Dale Scherger, Project Manager Testing Organization (TO)
(704)-947-7050 email: daleres@aol.com

Scherger Associates
12410 Willingdon Road
Huntersville, NC 28078

ADAM MARKIE - FIELD SUPPORT

Mr. Adam Markie
email: None
(810) 727-4115 (home)
(810) 727-7980 (work)
68661 Stoecker Lane
Richmond, MI 48062

NSF INTERNATIONAL – LABORATORY SUPPORT

Mr. Steve Williams,
Phone number: (734) 769-5357 email: williams@nsf.org

NSF INTERNATIONAL - QUALITY ASSURANCE SUPPORT

Bruce DeMaine, Manager, QA and Safety
Phone number: (734) 769-5143 email: demaine@nsf.org

Note: Mr. DeMaine may appoint a designee for some of the QA tasks.

NSF International
789 Dixboro Road
Ann Arbor, Michigan 48105

3.4 TECHNOLOGY VENDOR

The mercury removal technology being evaluated is the Mercury Removal Unit (MRU) manufactured and distributed by Dental Recycling North America, Inc. (DRNA). The vendor will be responsible for supplying all of the equipment needed for the VTP and will support the TO in ensuring that the equipment is properly installed and operated during the verification test period. Specific responsibilities of the vendor will include:

- Initiate application for ETV testing;
- Provide input to the verification testing objectives to be incorporated into the Verification Test Plan;
- Select the test site;
- Provide any available site data (e.g., representative historical flow and characterization data);
- Provide complete, field-ready equipment and the operations and maintenance (O&M) manual(s) typically provided with the technology (including instructions on installation, start-up, operation and maintenance) for verification testing;
- Provide any existing relevant performance data for the technology if it has been tested/operated at other locations;
- Provide of logistical and technical support as required;
- Provide assistance to the Testing Organization on the operation and monitoring of the Technology during the verification testing;
- Review and approve the site-specific Test Plan;
- Review and comment on the Verification Report; and
- Provide funding for verification testing.

The key contact for DRNA will be:

Mr. Marc Sussman
(212) 956-5188 email: mmsussman@aol.com

Dental Recycling North America, Inc.
P.O. Box 1069
Hackensack, NJ 07601
1-800-360-1001 www.drna.com
(The New York address is 145 West 58th Street, NY, NY 10019)

3.5 ETV TEST SITE

The host test site will be responsible for some record keeping and providing information on activities that may affect the characterization and verification test results. These responsibilities include:

- Provide logistical support and reasonable access to the equipment and facilities for sample collection and equipment maintenance;
- Notify the Testing Organization of any significant changes in dental practices that could affect the volume and composition of wastewater produced at the site; and,
- Record the tooth number and number of amalgam surfaces placed and removed, the flushing procedure used (chemicals used, volume and frequency) and when chair side traps or vacuum filters are changed.

3.6 TECHNOLOGY PANEL

Representatives from the Technology Panel will assist the Verification Organization in reviewing and commenting on the Verification Test Plan. The Panel will also provide technical and professional support if needed by the TO during all phases of the verification test period. The Panel will review and comment on the Verification Report and support the Verification Organization as needed.

3.7 STAKEHOLDER ADVISORY GROUP

The Source Water Protection Stakeholder Advisory Group will assist the Verification Organization in the review of the Verification Report.

4.0 TECHNOLOGY DESCRIPTION

The package treatment unit that will be evaluated during the verification test period is the DRNA Mercury Removal Unit (MRU). This unit is sold by DRNA as a complete package that can be installed upstream of the air/water separator of wet or dry vacuum systems commonly used at dental offices. As described below, the MRU is comprised of two main treatment components, a BullfroHg amalgam separator for particulate removal and a mercury filter unit containing an adsorbent material for soluble mercury removal. This combination of technologies addresses both insoluble and soluble mercury typically present in the wastewater from dental office vacuum systems.

Mercury amalgam is a major material used in dental offices throughout the United States. The amalgam can enter the wastewater at a dental office either during the removal process, when old amalgams are removed, or during the placement process when new amalgam is used during normal dentistry practice. In a modern dental office, a vacuum system is used to remove liquid that accumulates in the mouth during dental procedures. This liquid contains particles of mercury amalgam of varying size. A coarse chair side trap is used to remove very large particles and protect the vacuum lines from becoming plugged. The liquid and small particles are carried through the vacuum system to an air/water separator near the central vacuum pump. The wastewater carrying the mercury material is then discharged to the sanitary sewer or septic tank system along with other wastewater from the office or building. Most of the mercury present in the wastewater is in the particulate form (insoluble). However, data collected over the past few years has shown that a small amount of mercury will also be present in the soluble form.

4.1 DRNA MERCURY REMOVAL UNIT (MRU)

The DRNA Mercury Removal Unit is designed to remove mercury from dental wastewater. The DRNA MRU uses a two-step process to address both the insoluble and soluble mercury that is present in wastewater. The BullfroHg unit is a particle separator based on the sedimentation process, and the mercury filter unit contains a specific adsorbent material that is designed to adsorb soluble mercury from the wastewater. Figure 4-1 shows a picture of the MRU unit.

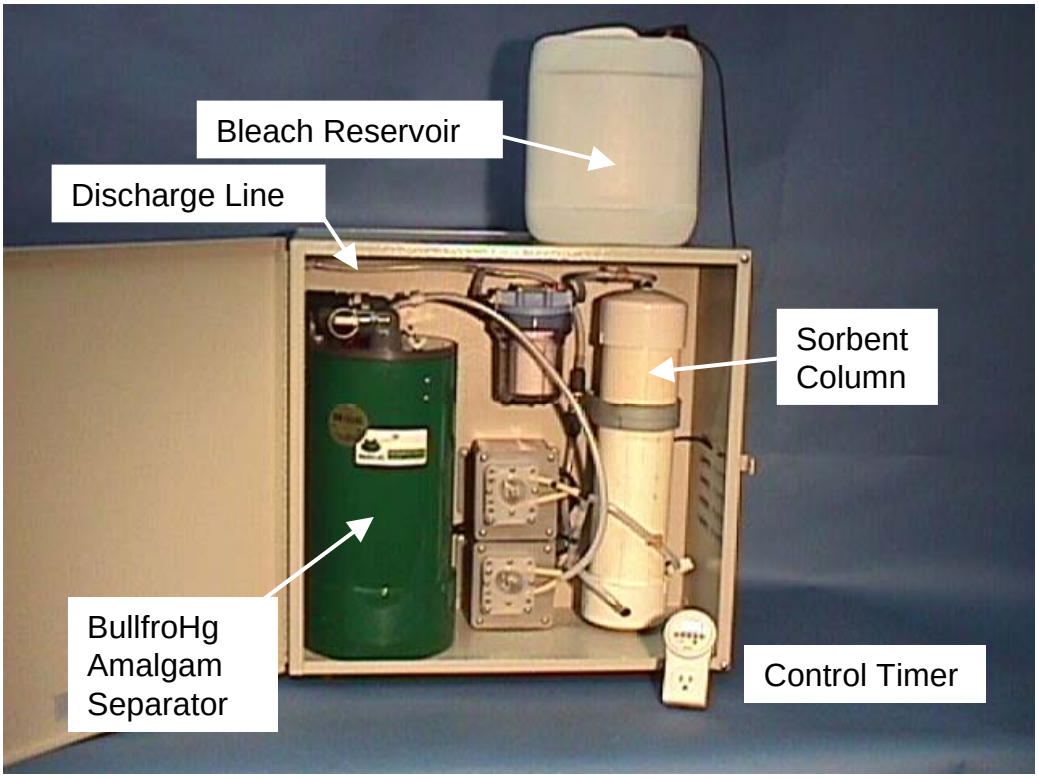
The BullfroHg air/water separator is designed to remove mercury amalgam particles from dental wastewater. The BullfroHg is a combined solid and air/water separator. Three-phase flow (air/water/solids) enters the BullfroHg from the dental office vacuum line. The BullfroHg is designed to be installed on the suction side of a dental vacuum pump. The entrained solids and liquids are retained within the BullfroHg while the air flows out to the system vacuum pump. Particles are allowed to settle for several hours after the vacuum system is shutdown at the end of the operating day. At the conclusion of the settling time, a timer activates a pump to pump the wastewater from the settling chamber through a fine particle filter (used to protect the adsorbent

material) and through the adsorbent filter. Solid amalgam particles remain trapped within the separator unit.

The settled and filtered wastewater is pumped through a fine particulate filter and then through an adsorbent column containing a mercury-specific adsorbent. Soluble mercury present in the wastewater is adsorbed onto this media and captured for future recycle. The treated wastewater then exits the adsorbent filter and is discharged to the sewer system.

The MRU is a self-priming system and will hold a vacuum when turned off. The pump can run dry without damaging the motor or the drive unit. A side benefit of using an MRU is that fine amalgam particles that can damage a vacuum pump are removed by the MRU. The MRU is designed so that if any problem occurs with the unit, flow will by-pass the MRU and allow continued operation of the dental suction system.

Figure 4-1: DRNA Mercury Removal Unit (MRU)



4.2 EQUIPMENT SPECIFICATIONS

The equipment specifications for the MRU are given below. Table 4-1 lists the components and parts that are included with an MRU as shipped to a dental location.

Physical Dimensions:	
Height	24 inch (61 cm)
Width	24 inch (61 cm)
Depth	12 inch (31cm)
Capacity (L per day / chairs)	10 / up to six (operatories)
Weight	90 lbs (41 kg)
Vacuum Rating	15 inch Hg
Pressure Rating	not rated
Temperature Range:	40-104 ^{o}F / 4-40 ^{o}C
Electrical Requirements:	
Input Voltage	4 amp, 120 VAC

Table 4-1. Equipment List

Description
MRU Enclosure containing: • BullfroHg™ Air/Water/Amalgam Separator • Twin peristaltic pumps with waste sensor • 10-liter bleach reservoir • Adsorbent column • Particle filter
Instruction Manual
Fittings & Hose: • 1” hose barb x female cam-lock fitting • 1” hose barb x male cam-lock fitting • 1” x 1” hose barb coupling • 1” hose clamps • 1” ID x 6-ft long vacuum hose • ¼” ID x 6-ft long discharge hose • 1” x 1” x ¼” hose barb for discharge connection • 1” x ¾” hose barb coupling (to adapt to ¾” ID hose)
Programmable Timer/Controller

Each standard MRU unit is designed to handle the flow for up to six (6) operatories (chairs). DRNA must be consulted for larger clinics.

4.3 OPERATION AND MAINTENANCE

The MRU is designed for ease of operation and minimal maintenance once installed in the vacuum system. The unit is plumbed into the vacuum system ahead of the vacuum pump and upstream of the air/water separator if one is present. The system is self-contained and operates automatically based on a timer that activates the pump used to remove water from the separator unit and pump it through the filter and adsorbent material. There is no daily operator intervention required other than periodic checks that the timer and pumps are working properly. The installation, operation and maintenance manual is presented in Appendix A.

Maintenance activities are minimal for the MRU. The large surface area of the adsorbent provides possible sites for biological growth. If biomass builds up on the adsorbent it can reduce the effectiveness of the adsorbent for the removal of soluble mercury. The biomass can also cause the column to plug, reducing the flow rate of treated wastewater through the unit. A bleach solution is used to disinfect the adsorbent system and help reduce clogging. Bleach can affect the solubility of mercury, causing particulate mercury to be dissolved or leached into solution. The use of bleach in this application, however, should not have an impact on mercury solubility as the bleach is added after the separation step and the particulate filter. Only soluble mercury should present at this location in the process. This solution needs be prepared periodically (about once per month is normal use) and placed in the container that is supplied with the MRU. Replacement should occur whenever the volume in the container becomes low. This solution is one part commercial bleach and one part water. The tubing that runs through the pump needs periodic replacement (approximately once per year), as it will become worn over time. The recommended maintenance activities and schedule are shown in Table 4-2.

Table 4-2. Recommended Maintenance Schedule

Item	Required Maintenance	Recommended Interval*
Pump	Replace pump tubing with new section of tubing.	12 months
Bleach Reservoir	Add 1 part commercial bleach, 1 part water.	Check volume weekly
BullfroHg™ Separator	Recycle	6 to 12 months
Adsorbent Column	Recycle	6 to 12 months
Particle filter	Replace	6 to 12 months

The MRU system is designed so that operators do not come in contact with any residues or have to open any mercury contaminated equipment. DRNA ships a complete replacement adsorbent column, filter and BullfroHg when it is time to recycle these devices. When the replacements arrive, the operator exchanges the new BullfroHg, adsorbent column, and filter for those in the MRU and ships the used units back to DRNA. The residues from these units are then removed from the units and recycled/reclaimed.

4.4 VENDOR CLAIMS

DRNA states in its literature that the mercury amalgam separator is effective at capturing 95% of all particles that are greater than 10 micron in size. DRNA states that this typically amounts to 95% of the total mercury sent to the unit. Further, the mercury specific adsorbent filter typically reduces the mercury concentration in the treated wastewater to below detection limits (author's statement – MDL for mercury is typically less than 0.2 ug/l).

This verification test plan will not measure particle size distribution, but will measure the total mercury load (soluble and insoluble) in the wastewater during the characterization period. The verification test period will measure the total mercury (soluble and insoluble) in the treated wastewater after the MRU. The results of the verification will determine the amount of mercury removed by the MRU during operation at the dental office.

5.0 WORK PLAN AND PROCEDURES

The Work Plan and Procedures for verification testing of the DRNA MRU have been developed to obtain field and analytical data to meet the objectives of the VTP. The Work Plan includes several tasks designed to verify the mercury removal capability of the MRU and to obtain information on the installation, operation, and maintenance requirements of the MRU. There are three distinct phases of fieldwork that need to be accomplished as part of the Work Plan and VTP. The three phases are initial characterization of the wastewater, installation and start-up of the MRU, and verification testing with the MRU operating and treating the wastewater.

Each of these Work Plan elements is described in this section. In addition to a description of sample collection methods, equipment installation, and equipment operation, this section also describes the analytical protocols. Quality Assurance and Quality Control procedures, and data management approach will be presented in subsequent sections of the VTP.

5.1 INFLUENT CHARACTERIZATION

5.1.1 Introduction

The purpose of influent characterization is to obtain an understanding of the influent wastewater flow and water quality characteristics before the verification test of the DRNA MRU. There is currently no water quality data available for the wastewater from the test site. Therefore a thorough characterization of the influent (untreated) wastewater is needed to provide sound information for determining the mercury removal effectiveness of the MRU. Influent characterization will occur over a 25-day business period (six weeks and one day, four day operating week) before the MRU is installed for testing.

5.1.2 Objectives

The objectives of influent characterization are to:

- Determine the daily flow of the wastewater stream to be used for verification testing;
- Evaluate the concentrations and daily mass loading of mercury in settleable, particulate and soluble forms;
- Determine operational conditions for the MRU technology;
- Record and document all influent characterization conditions and results; and,
- Identify any required modifications to the Work Plan prior to beginning verification of the MRU (adjustments in sampling, analysis, etc.).

5.1.3 Sampling Location, Container Type and Sampling Frequency

The dental office selected as the site for this VTP has a dry vacuum system with an air/ water separator just upstream of the vacuum pump. A 10-liter vacuum-rated polypropylene container

will be used for the sample collection container. The container will be plumbed into the vacuum system just prior to the current air/water separator collection vessel. The collection container will be set up to maintain the vacuum in the system. The entire flow from a 24-hour period of operation will be collected to characterize the wastewater. Collection of the entire flow eliminates the concern about obtaining unrepresentative samples that may contain large particles and eliminates the need to consider flow weighted composite samples versus time composite samples. The use of the 10-liter container will ensure that sufficient volume is available to contain all of the flow for a full day of office activities. The current typical flow in the system is 2-3 liters per day (½ to ¾ gallons) with an additional 2.5 liters of flushing solution on line cleaning days. The sampling container is directly upstream of the existing air/water separator. Therefore, in the case the bottle was to overfill, the extra wastewater would be collected in the current system prior to reaching the vacuum pump. If the sample bottle does overflow, the sample will be discarded, and a larger bottle will be obtained and used for future sample collection.

The sample location for this VTP is located upstream of the air/water separator in contrast to the Verification Protocol that calls for the sample to be collected downstream of the separator. This change has been made for two reasons. First the air/water separator in this office holds the wastewater until the vacuum system is shutdown. At that time the wastewater is discharged from the separator. While this water could be collected as the daily sample, there is no good way to rinse and clean the air/water separator at the end of each day. To clean the separator would require that the unit be disconnected from the system, the top opened and the unit cleaned and re-installed. Second, the DRNA MRU is designed to be installed before the air/water separator. Therefore, in order to match the influent characterization location to the inlet location of the MRU during the verification test, the sample bottle should be located before the air/water separator. In fact, by locating the sample bottle at this location, the wastewater sampled during the influent characterization will be identical to the wastewater that is entering the BullfroHg separator in the MRU. The elevation of the sample container inlet (approximately three feet above the floor) will be at approximately the same height as the inlet to the MRU air/water/solid separator when it is installed at the same location. The wastewater being collected in the sample container will also be the same wastewater that is normally collected in the current air/water separator.

The sample container will be changed daily. The daily sample, representing all of the previous 24-hour flow, will be capped and prepared for shipment to the laboratory. A chain of custody form will be prepared and signed by the sampler. Also, a custody seal will be placed over the cap of the container. The sample bottle will be placed in a cooler with ice and will remain cool during shipment to the laboratory. The wastewater will be delivered to the NSF laboratory in an expeditious manner and will generally arrive within 24 hours of collection. The entire sample will then be transferred to a plastic settling tank. The sample will be settled for a minimum of eight hours and a maximum of sixteen hours. The complete sample settling and handling procedures are presented in the laboratory methods section.

The sampling container(s) and any fittings will be thoroughly cleaned by the laboratory and returned to the field for reuse. Cleaning will involve scraping to remove any solids adhered to the

surface of the container or fittings, rinsing with mercury-free water (<0.2 ug/L) and a final 1% nitric acid rinse using mercury-free water. Any solids collected during cleaning and the rinse water will be added to the sample being settled and included in the analysis. The acid rinse will not be added to the settling sample as it could cause some of the mercury in the sample to become soluble during the settling time. The method used to clean the sampling container(s) is described in Appendix B.

New coarse chair side traps will be installed just before the start of the influent characterization program. These traps will be changed once per week in accordance with normal office procedures during the testing period. The trap material will be placed in the special used trap storage container that normally is shipped out for mercury recycle. During the two test periods, the trap material will be sent to the laboratory and the particles of mercury amalgam and related materials will be weighed. Paper and other debris will not be weighed as part of the sample. A log will be maintained by the dental assistant to document when the coarse traps are replaced. A copy of this log will be sent to the laboratory with the sample(s) and also a copy will be sent to the TO Project Manager.

A DRNA MRU system is currently installed at the site. The MRU is installed downstream of the air/water separator and receives a batch discharge of wastewater from the air/water separator at the end of each day. This existing system will remain connected during the influent characterization test. Its location, downstream of the vacuum system air/water separator will in no way impact the characterization sample collection. The dental office also uses the DRNA Particle Trap at each dental chair. The Particle Trap units will be disconnected and by-passed during the characterization test and verification test periods. The vacuum line will run directly from the chair through a standard coarse chair side trap and then to the main header. The sample collection container will be located in the main header just before the air/water separator and the vacuum pump. Following completion of the verification test program, the Particle Traps will be re-connected at each chair location. The Particle Trap is not part of this verification test.

5.1.4 Analytical Testing and Record Keeping

A minimum of 25 samples will be collected over a six to seven week period. Table 5-1 presents the influent parameters to be measured for the solids collected and liquid sub-samples. Industry standard procedures (USEPA Methods [4] or Standard Methods [5]) will be used for sample analysis where applicable. Any modifications to USEPA or Standard Methods will be detailed, together with the rationale as to why the method was modified. All samples will be analyzed in triplicate for mercury. For solid mercury analysis, the method used for digestion will be validated using a standard sample. Details of analytical methods and laboratory QA/QC are presented in Section 6, Section 7, and Appendix B.

Table 5-1: Summary of Influent Analytical Requirements

Parameter	Solid Fraction[1]	Liquid Fraction[1]
Core parameters		
Volume (liters) [2]		X
pH		X
Approximate volume of solids (particle(s)) (mL) [3]	X	
Wet weight of solids (grams)	X	
Solid (Particle) mercury (mg) [4]	X	
Total mercury (mg/L) [5]		X
Soluble mercury (mg/L) [5]		X
Chair side Trap Material – weigh (grams)[6]	X	

Note:

(1) Minimum of 25 samples, each a complete sample of all the waste generated over a 24 hour period.

(2) Total volume of wastewater and rinse water recorded separately.

(3) Volume estimated after as much as possible of the liquid fraction has been removed.

(4) Digestion required before analysis.

(5) Analysis carried out on a representative sub-sample of the liquid fraction.

(6) Chair side trap material will be weighed- paper and non-amalgam/tooth type debris will be excluded

The dental office staff will maintain a record of the tooth number and number of amalgams and surfaces placed and removed each day. The dental assistant will fill out this log. A copy of the log will be obtained each day when the sample is collected. The copy of the log will be sent with the sample chain of custody to the NSF laboratory. The laboratory will retain the log and submit a copy of the log with the analytical data to Scherger Associates.

The dental assistant is currently responsible for the flushing procedure performed on a weekly basis. Mr. Markie, the TO field representative will observe the dental assistant performing the procedures and provide training if necessary to ensure consistent procedures are followed and accurate logs maintained. The dental assistant will maintain a log showing the chemicals used and the volume of flushing chemical used for each chair. Mr. Markie will obtain a copy of this log at the end of each week and he will forward a copy to Scherger Associates. The same procedure will be used for logging changes to the coarse chair side traps. The dental assistant

will maintain the log. Mr. Markie will obtain a copy weekly. He will forward a copy of the log to Scherger Associates and a copy of the trap log will also accompany the trap material samples sent to the laboratory.

5.1.5 Characterization Review – Notice to Proceed with Verification Test

There is no historical data on the wastewater characteristics at this dental office. Therefore, the characterization results need to be reviewed prior to the beginning of the verification test. This review will determine that the wastewater characteristics are typical of a dental office and will provide loadings to the MRU during the verification test. It is expected that this review will be performed within a few days of completion of the characterization test so that the installation of the MRU and verification test start can begin expeditiously. The VO review the data and results from the characterization test and provide a written notice (by email, fax, or letter) to the TO to proceed with the MRU installation and verification test. If for some reason there are problem uncovered in the characterization results, testing will be delayed until the issue are resolved.

5.2 MRU INSTALLATION AND COMMISSIONING

5.2.1 Introduction

DRNA has provided an installation, operation, and maintenance manual for the MRU. This manual is presented in Appendix A. A new MRU unit with all components typically shipped with an MRU order will be delivered to the site by DRNA. The installation and startup are straightforward as described below and in the installation manual.

5.2.2 Objectives

The objectives of the installation and start-up phase of the Work Plan are to:

- Install the Mercury Removal Unit (MRU) in accordance with the DRNA O&M manual;
- Start-up and test the MRU to ensure all processes are operating properly, timers are set for proper automatic operation, and eliminate any leaks that might occur during the installation;
- Make any modifications needed to achieve operation; and,
- Record and document all installation and start-up conditions prior to beginning the verification test.

5.2.3 Installation and Startup Procedures

Mr. Adam Markie will perform the installation and start-up of the MRU with support as needed from DRNA. The MRU, as shown previously in Figure 4-1, is a self-contained unit that will only require connections to the vacuum system using standard tubing and fittings. Installation will be at the same location in the vacuum system as the sample container used for the characterization

test. At the end of the characterization test, the sample container connections will be removed and the proper connections for the MRU will be installed. The entire installation is expected to take less than five hours.

A new, clean MRU system will be installed in the vacuum line upstream of the existing air/water separator, as recommended by DRNA. The vacuum line is a one-inch line and will be connected to the inlet of the MRU with a one-inch connection, which is the standard inlet size for the MRU. The outlet vacuum port on the MRU will be connected to the one-inch line running to the current air/water separator. The air/water separator will remain in-line downstream of the MRU as a protection for the vacuum pump in the case the settling unit should overflow.

The internal units and pumps in the MRU come completely plumbed and ready for operation. Tubing connects the outlet port of the BullfroHg separator to a small pump, which pumps the water through the particle filter and the adsorbent filter unit. The pump is activated at a preset time and the settled wastewater is pumped through the adsorbent column. The treated effluent discharge line from the MRU will be directed into a 10-liter polypropylene container that will collect all of the effluent from a twenty-four period of dental office operation. The sample bottle will be located at the utility sink so that in the case of an overflow the treated water will discharge to the sink and the sewer system.

Once the installation is complete, the timer will be set to activate the pump at three am. The waste level sensor in the separator will shut the pump off when all wastewater is removed from the separator. The sensor and timer will be checked for proper operation in accordance with the installation manual. The entire system will then be wet tested. Clean water will be placed in the separator unit and the vacuum lines reconnected with the fast connect/disconnect fittings. The manual operation button will be pushed which will activate the pump and pump clean water through the particle filter, the adsorbent filter, and into the sample collection bottle. The MRU will be inspected for leaks. Once the system checks are completed, the MRU is ready for operation and the verification testing can begin. The flush water used for this test will be collected in the sample bottle and sent to the laboratory for analysis following the same procedures as for the normal verification test samples.

A field logbook will be used to record all observations and conditions regarding the equipment and the site. During installation and MRU set up, the installer will take notes and log observations regarding the installation and system operation. Observation of the condition of the unit upon receipt and condition of the fittings and connections within the unit will be made. Any difficulties with the installation will be logged and solutions to any installation problems will be noted. Finally, observations regarding the start-up of the unit, leak checks, timer and pump checks, etc. will be made and written in the field operation log.

Figure 5-1 shows a schematic diagram of the DRNA system installation.

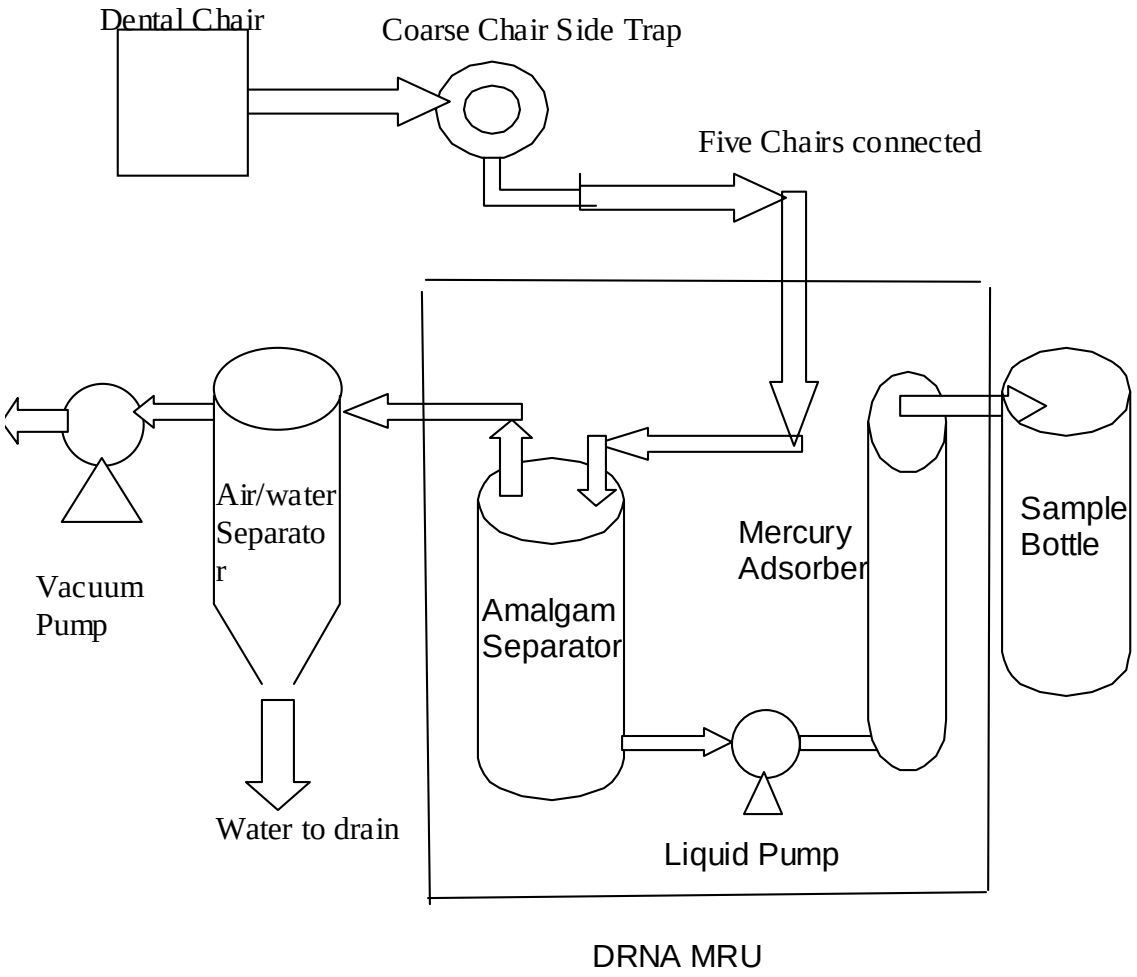


FIGURE 5-1: MRU Installation Schematic Diagram

5.3 VERIFICATION TESTING

5.3.1 Introduction

The treatment performance of DRNA MRU will be evaluated under field conditions, and will be documented during verification test. The treated wastewater effluent discharged from the MRU will be sampled and analyzed. Residuals retained by the MRU in the separator, particle filter, and adsorbent filter (three separate samples) will be measured individually and analyzed individually at the end of the verification test. All samples of wastewater and residue will be analyzed for mercury to determine the performance of the MRU for the removal of mercury in the dental office wastewater from the vacuum system. Operation and maintenance conditions will be monitored and documented. Verification testing conditions, observations and results will be presented in the Verification Report.

5.3.2 Objectives

The objectives of verification testing are to:

- Evaluate the treatment performance of the MRU for the removal of soluble and insoluble mercury, operating under standard conditions as specified by DRNA;
- Evaluate the MRU operation and maintenance requirements; and,
- Record and document test conditions, observations and results

5.3.3 Sample Location, Sampling Approach and Frequency

5.3.3.1 Treated Water Sample Collection

The installed DRNA MRU collects all of the wastewater from the vacuum system and contains the liquid and solids in the BullfroHg separator. After several hours of settling, the liquid is pumped through the particle filter and adsorbent filter unit prior to the start of the next day of operation in the dental office. The discharge from the MRU then normally flows to the sewer system in the building. The sampling location for the daily treated-water discharge will be the end of the discharge tube from the unit. The discharge tube will be secured in 10-liter polypropylene sample bottle that will collect the entire discharge. Each sample will represent a 24-hour period and match with one day of operation at the dental office, followed by overnight treatment in the MRU.

Collection of the entire flow for each 24-hour period eliminates concern about obtaining "representative" samples and eliminates the need to consider flow weighted composite samples or time composite samples. The use of the 10-liter container will ensure that sufficient volume is available to contain all of the flow for a full day of office activities. The current typical flow in the system is 2 – 3 liters per day (½ to ¾ gallons) with an additional 2.5 liters of flushing solution on line cleaning days. The sampling container will be placed in the utility sink next the MRU. The MRU BullfroHg unit has a capacity of 10 liters. Therefore it is highly unlikely the sample bottle will overflow. If the sample bottle was to overfill, the treated wastewater will enter the sewer system through the utility sink drain, which is the same location as the discharge from the MRU during normal operation at this facility. If the sample bottle (or the BullfroHg separator) does overflow, the sample will be discarded, and testing stopped until the problem is resolved.

Effluent samples will be collected for 25 operating days to yield 25 samples for analysis. At the end of each 24-hour period of office and MRU operation, the filled sample bottle will be replaced with a clean sample bottle. The filled sample bottle will be capped and prepared for shipment to the laboratory. A chain of custody form will be prepared and signed by the sampler. Also, a custody seal will be placed over the cap of the container. The sample bottle will be placed in a cooler with ice and will remain cool during shipment to the laboratory. The wastewater will be delivered to the NSF laboratory in an expeditious manner and will generally arrive within 24 hours of collection. The entire sample will then be transferred to a plastic settling tank (12inches x 12inches x 12 inches). The sample will be settled for a minimum of eight hours and a maximum of twelve hours. The SOP for the sample settling and handling procedure is presented in Appendix B.

The sampling container will be thoroughly cleaned by the laboratory and returned to the field for reuse. Cleaning will involve scraping to remove any solids adhered to the surface of the container, rinsing with mercury-free water and a final 1% nitric acid rinse using mercury-free water. Any solids collected during cleaning will be added to the sample being settled and included in the analysis. The rinse water (prior to acid cleaning) will be added to the sample as well. The acid rinse will not be added to the sample as it could cause mercury to become soluble during the settling process. The method used to clean the sampling container(s) is described in Appendix B.

5.3.3.2 Residuals Sample Collection

The DRNA MRU is designed to retain solid amalgam and other particles in the BullfroHg separator and the particle filter. The system is sized to retain these residuals for a six month to one-year period. At that time the separator, particle filter, and adsorbent filter units are retuned to DRNA for reclamation of the mercury and cleaning. Cleaned units are provided to the dental office to replace the used units.

Based on this normal operating condition, the residuals from the separator, particle filter, and adsorbent filter will be collected one time at the end of the verification test. At the end of the

verification test and after the final line flushing to remove any residues in the vacuum lines, the pump will be manually activated to remove any liquid present in the separator. The pumped water, if any, will be collected in the sample bottle for the last day of the verification test. Once all water has been removed, the separator unit, the filter from the particle filter, and the adsorbent unit will be disconnected and removed from the MRU housing. Replacement units and filters will be provided by DRNA and will be installed in the MRU. The units used during the verification test will be sent to the NSF laboratory for residuals sampling and analysis.

The separator unit is designed with a removable lid that allows ready access to the unit. The unit was designed for ease of cleaning and reuse. The laboratory will open the unit and remove all of the residue from the separator. The separator will be scraped and cleaned to remove all of the residue. All scrapings and residue obtained during the cleaning process will be added to the separator residue sample. After scraping, the separator will be rinsed and the rinsate filtered to collect any additional solids. All residues (any solids from the separator cleaning) will be added to the separator residue. There should be no liquid present in the separator after the shutdown procedures are followed. Therefore, there will be no need to settle the residual sample after collection in the laboratory.

The particle filter will contain small particles that did not settle in the separator. The filter will be an additional residue sample that will be analyzed for mercury. The entire filter will be digested in the mercury procedure in order to determine the mass of mercury removed by the particle filter. The filter itself may not completely dissolve during the digestion step, but this is not necessary, as any particulate mercury will become soluble under the strong acid digestion procedure.

The adsorbent material will adsorb soluble mercury that may be present in the wastewater. The adsorbent will be removed from the filter housing and weighed in the laboratory. The adsorbent will then be thoroughly digested, mixed and homogenized. Three representative samples of the homogenized adsorbent will be collected and analyzed for mercury content. This will provide a basis for determining the amount of mercury captured on the adsorbent during the verification test.

New coarse chair side traps will be installed just before the start of the verification test. These traps will be changed once per week in accordance with normal office procedures during the testing period. The chair side trap material will be placed in the special container used reclamation in accordance with current procedures at the dental facility. The trap material will be sent to the laboratory and the material weighed. Paper and related debris (non-amalgam and tooth related) will be segregated and not included in the weighed sample. A log will be maintained to document when the coarse traps are replaced. Copies of the log will accompany the material to the laboratory and also will be sent to the Project Manager (TO).

5.3.4 Analytical Testing and Record Keeping

A minimum of 25 samples will be collected over a six to seven week period. Table 5-2 presents the effluent parameters to be measured for the solids collected and liquid sub-sample. Industry standard procedures (USEPA Methods[4] or Standard Methods[5]) will be used for sample analysis where applicable. Any modifications to USEPA or Standard Methods will be detailed, together with the rationale as to why the method was modified. All samples will be analyzed in triplicate for mercury. For solid mercury analysis, the method used for digestion will be validated using a standard sample. Details of analytical methods and laboratory QA/QC presented in subsequent sections.

Table 5-2: Summary of Effluent and Residual Analytical Requirements

Parameter	**Effluent[1, 2]**		**Residuals**	
	Solid Fraction	**Liquid Fraction**	**Solid Fraction**	**Liquid Fraction**
Core parameters				
Volume (liters) [3]		X		X
pH		X		X
Approximate volume of solids (particle(s)) (mL) [4]	X		X	
Wet weight solid particles (grams)	X		X	
Solid (particle) mercury (mg) [5]	X		X	
Total mercury (mg/L) [6]		X		X
Soluble mercury (mg/L) [6]		X		X
TCLP[7]			X	
Chair side Trap material weighed (grams) [8]			X	

Note:

(1) Minimum of 25 samples, except for TCLP analysis.

(2) Collect all of the effluent over a 24-hour period.

(3) Total volume of wastewater and rinse water recorded separately.

(4) Volume estimated after as much as possible of the liquid fraction has been removed.

(5) Digestion required before analysis.

(6) Analysis carried out on a representative sample of the liquid fraction.

(7) Toxicity characteristic leaching potential, as per USEPA method SW 846 1311. Required for minimum of one sample.

(8) Chair side trap material will be collected and weighed. Paper and non-amalgam/tooth debris will be excluded from the sample.

The dental office staff will maintain a record of the tooth number and number of amalgam and surfaces placed and removed each day. The dental assistant will fill out this log. A copy of the log will be obtained each day when the sample is collected. The copy of the log will be sent with the sample chain of custody to the NSF laboratory. The laboratory will retain the log and submit a copy of the log with the analytical data to Scherger Associates.

The dental assistant is currently responsible for the flushing procedure performed on a weekly basis. Mr. Markie, the TO field representative, will review the procedures with the assistant and provide any training that may be needed for either the flushing procedure or record keeping during the project. Procedures will be reviewed to ensure consistent procedures are used throughout the characterization and verification tests. The dental assistant will maintain a log showing the chemicals used and the volume of flushing chemical used for each chair. Mr. Markie will obtain a copy of this log at the end of each week and he will forward a copy to Scherger Associates. The same procedure will be used for logging changes to the coarse chair side traps. The dental assistant will maintain the log. Mr. Markie will obtain a copy weekly. He will forward a copy of the log to Scherger Associates.

5.3.5 Operation and Maintenance Performance

Both quantitative and qualitative performance of the MRU will be evaluated during the verification test. The MRU is self-contained and is designed to have minimal operator intervention once the installation is complete. As stated earlier, a field logbook will be maintained that will include all observations made during the installation and startup of the MRU. This field logbook will be maintained throughout the verification test. Observations regarding the condition of the MRU, any changes in setup or operation (timer adjustments, filter changes, etc.), or any problems that require resolution will be fully recorded in the logbook by the field personnel. If a filter change is required, the date and time of the replacement shall also be required. All maintenance activities, if any, that are performed during the verification test will be documented in the field logbook.

Qualitative operation and maintenance performance information will include, but are not limited to, the following:

- Observations regarding ease of operation;
- Observations regarding the effect of the MRU, if any, on the operation of the vacuum system;
- Documentation of any operating problems encountered during testing;
- Quality of the O&M manual (e.g., actual experience in the field compared to that indicated in the manual, clarity of instructions); and,
- Observations regarding labor requirements.

These qualitative observations and information will be recorded in the logbook and will be discussed in the verification report.

There are several quantitative performance measures that will be recorded or calculated for the operation of the MRU. The information that will be recorded in the logbook will include the following:

- Duration (in hours) of any clean-out operations (none are expected based on equipment design, length of test, and vendor information);
- Frequency and duration (in hours) of any preventative or breakdown maintenance activities;
- Electrical consumption for the two pumps will be estimated by estimating the operating time of the pumps (timer controlled), and calculating kilowatt hours consumed by using the electrical rating for the pumps and hours of operation;
- Chemical consumption of the bleach cleaning solution will be monitored by logging the quantity of solution made and the remaining material in the container at the end of the verification test; and,
- Records of any other consumables used by the MRU over the test period (none expected).

6.0 ANALYTICAL PROCEDURES

This section describes the analytical procedures that will be used to determine the mercury concentrations in the liquid and solid samples collected during the characterization and verification testing. Sampling handling, sample preparation (including settling), and other related activities are described. The actual sample locations, sampling procedures, and field procedures have been described in Section 5.

Samples of the wastewater collected during the characterization and verification tests will be collected directly into the sample container (10-liter polypropylene container) and will represent the entire 24-hour flow at the facility. This sample container will be delivered to the laboratory so that no sub-sampling or split sampling will be needed in the field. The samples will be received at the laboratory under chain of custody. The laboratory will log the samples into their system, inspect the samples to ensure the custody seals are intact, and sign the custody form.

All of the wastewater samples received during test period will be subjected to an eight to sixteen hour settling period to separate settleable material from the liquid. The settled material will represent one sample and the decanted liquid will be a second sample. The laboratory will analyze the settleable solids for total mercury. The liquid portion will be analyzed for total and soluble mercury as shown in Tables 5-1 and 5-2.

A settling chamber will be used to contain and settle the entire sample. This chamber will be a plastic tank with dimensions of 12inches X 12inches x 12inches. The volume of sample in the sample container will be measured and the entire sample placed in the settling chamber. Solid residue will be removed from the sample container walls by scraping and then the container will be rinsed with mercury free water (0.2 ug/L). All solid residue and rinse water (measured volume) will be added to the settling chamber. The sample will settle for eight to sixteen hours. After settling, the liquid phase of the sample will be decanted to a clean sample container using Tygon tubing. The volume of the liquid sample will be determined and logged. This sample will be labelled as the liquid sample. The remaining solid residue and associated liquid will be measured for volume and weight. This residue will be placed in a sample bottle labelled as the solid sample for that day's sample. The laboratory operating procedure for the settling procedure is presented in Appendix B.

The solid sample will be analyzed for total mercury using the USEPA procedure for solid samples, Method 7471A. Three representative sub-samples will be obtained and used for the mercury analysis. Method 7471A includes an acid digestion step to dissolve the mercury prior to the actual analysis. The laboratory SOP for this procedure is in Appendix B. In order to insure that the digestion procedure and analysis are working properly, a solid matrix sample with a known amount of mercury will be processed at the beginning of the characterization test with the first samples and will be repeated again after twenty samples have been processed. This will ensure that at least two (2) performance evaluation samples will be collected for each test period (characterization and verification). Also, a sample of the mercury amalgam being used at the dentist office will be obtained and analyzed using the same procedures. The test on the manufacturer's amalgam will be compared with the reported mercury concentration in the amalgam. These QC samples will help verify the accuracy of the procedure.

An aliquot of the liquid sample, prior to preservation with nitric acid, will be filtered through a 0.45-micron glass fiber filter that has been pre-washed with nitric acid to remove any contamination and then rinsed with mercury free water.. The filtered sample will be analyzed for mercury using USEPA procedure 7470A. These results will represent the soluble mercury present in the water. An aliquot of the liquid sample will also be analyzed for total mercury using Method 7470A. The results of both the soluble and total mercury analysis will be reported. The insoluble mercury concentration will be calculated by subtracting the soluble mercury from the total mercury concentration. The laboratory SOPs for these Methods is included in Appendix B.

The residues collected at the end of the verification study from the separator, the particle filter, and the adsorbent filter will also be tested for mercury using USEPA method 7471A. The entire separator and adsorbent units will be sent to the laboratory for removal of the residue material. The particle filter is a filter held in a filter holder. The entire filter (without the holder) will be placed in a zip lock plastic bag and sent to the laboratory.

The separator has a removable lid to provide access to the inside of the unit and for cleaning. The lid will be removed and the solid material collected from the bottom of the unit. Scraping of the sidewalls and bottom will remove any remaining residue in the unit. The unit will be rinsed and the lid replaced. The solid residue collected will be weighted and the volume determined. The residual will then be placed in a sample bottle and refrigerated. When the laboratory is ready to analyze the samples, three representative sub-samples will be taken from the sample and analyzed for mercury using USEPA method 7471A. These triplicate samples will help insure that representative results are obtained. QA/QC procedures will be the same as for the settled solids samples and will include the use of a solid matrix sample with a known mercury concentration.

The adsorbent material is a proprietary mix of three different adsorbents layered in the filter. All of the adsorbent will be removed from the filter housing. The adsorbent will then be well mixed in order to obtain a homogenous sample. Three representative sub samples will be collected for mercury analysis. USEPA Method 7471A will be used following the same procedures described above and in the laboratory SOP in Appendix B. A special QC check will be performed for the adsorbent material. DRNA will supply samples of virgin adsorbent material and information on isotherm studies performed as part of the product development program. The isotherm data will used to determine the concentration of mercury solution needed to “load” mercury onto the column. A known amount of mercury in solution (based on the isotherm data) will be prepared and adsorbent added to the solution. The mixture will be stirred for 4 hours allowing the adsorbent to adsorb mercury from solution. The solution will then be filtered through a glass fiber filter. The adsorbent on the filter will be analyzed using Method 7471A. The liquid will also be analyzed for total mercury using Method 7470A. These results will allow for a calculation to compare the amount of mercury adsorbed from solution with the actual measured amount found in the adsorbent sample. This procedure will confirm the ability of the method to measure the mercury trapped on the adsorbent. This QA/QC work will be performed prior to the start of the verification test. If recovery of mercury from the adsorbent is a problem then alternative test procedures will be explored. A stronger digestion procedure may be needed or a thermal procedure for mercury analysis may need to be used through a contract laboratory.

The particle filter will be analyzed using Method 7471A with the entire filter being digested in the procedure. Depending on the weight and volume of the filter media, a larger quantity of digestion fluid may be needed. This is the only variation expected in the normal solid test

procedure for mercury. The total weight of mercury trapped on the filter will be determined. The filter itself may not completely dissolve during the digestion procedure. However, this is not necessary as any mercury present in particulate form will be dissolved by the strong acid and will be measured in the digestate.

In addition to mercury analysis, pH will be measured on all liquid samples collected during the test periods. pH will be measured using USEPA method 150.1. The laboratory SOP for pH is given in Appendix B.

The laboratory will be responsible for providing clean sample containers for both the characterization test and verification test. Scraping the bottles and rinsing the containers as described above will clean the polypropylene containers and should result in mercury free bottles or very low levels of residual mercury. At the beginning of the test, a sample bottle will be filled with six liters of water containing 500 ug/l of mercury. The bottle will sit over night and then be emptied of the mercury solution. The bottle will then be cleaned using the standard procedures. This clean bottle will be filled with six liters of mercury free water (<0.2 ug/l) and allowed to sit overnight. The "blank" water will then be analyzed for mercury to demonstrate that the cleaning procedure is effective in removing mercury from the bottle. Twice during each of the two test periods, after 10 samples and after 20 samples, a cleaned bottle will be filled with six liters of mercury free water (<0.2 ug/L) and allowed to sit over night. The water will then be analyzed as a field blank for QC purposes. These blank water tests will document any problems with mercury contamination in the sample bottles.

The laboratory will report all results with all associated QC data. The results will include all volume and weight measurements for the samples, field blank results, method blanks, spike and spike duplicate results, results of standard check samples and special QC samples, and appropriate calibration results. All work will be performed within he established QA/QC protocol as outlined in the laboratory SOPs and the NSF Laboratory QA/QC Plan. Any deviations from the standard test procedures or difficulties encountered during the analyses will be documented and reported with the data.

Table 6-1 summarizes the methods that will be used by the laboratory and gives the expected detection limits that will be achieved by these methods.

Table 6-1: Analytical Methods and Detection Limits

Matrix	Parameter	Reference Method	Detection Limit
Liquid	pH	150.1	N/A
	Total Mercury	7470A/241.1	0.2 ug/L
	Soluble Mercury	7470A/241.1	0.2 ug/L
Solid	Total Mercury	7471A/245.5	0.25 mg/kg
	TCLP/Mercury	1311/ 7470A/241.5	1.0 ug/L

7.0 QUALITY ASSURANCE AND QUALITY CONTROL – PROJECT PLAN

The purpose of this section is describe the quality assurance/quality control program that will be used during the VTP to ensure that data and procedures are of measurable quality and support the quality objectives and test plan objectives for this verification test. The quality assurance activities and scope are based the guidance provided in the Protocol for the Verification of Mercury Amalgam Removal Technologies. The plan has been developed with guidance from the USEPA's Guidance for Quality Assurance Project Plans and Guidance for the Data Quality Objectives Process. The QA/QC plan is tailored to this specific test plan and requirements for verification of the DRNA MRU in this application. The QA/QC plan is written as part of the Verification Test Plan and should be read and used with the VTP as a reference. The VTP contains descriptions of various requirements of the QA/QC Plan and they are incorporated by reference at several locations.

7.1 VERIFICATION TEST DATA – DATA QUALITY INDICATORS (DQI)

Several Data Quality Indicators (DQI) have been identified as key factors in assessing the quality of the data and in supporting the verification process. These indicators are:

- Precision
- Accuracy
- Representativeness
- Comparability
- Completeness

Each DQI is described below and the goals for each DQI are specified. Performance measurements will be verified using statistical analysis of the data for the quantitative DQI's of precision and accuracy. If any QA objective is not met during the tests, an investigation of the causes will be initiated. Corrective Action will be taken as needed to resolve the difficulties. Data failing to meet any of the QA objectives will be flagged in the Verification Report and a full discussion of the issues impacting the QA objectives will be presented.

7.1.1 Precision

Precision refers to the degree of mutual agreement among individual measurement and provides an estimate of random error. Analytical precision is a measurement of how far an individual measurement may deviate from a mean of replicate measurements. Precision is evaluated from

analysis of field and laboratory duplicates and spiked duplicates. The standard deviation (SD), relative standard deviation (RSD) and/or relative percent difference (RPD) recorded from sample analyses are methods used to quantify precision. Relative percent difference is calculated by the following formula:

$$RPD = [(C_1 - C_2) / (C_1 + C_2) / 2] \times 100\%$$

Where:

C_1 = Concentration of the compound or element in the sample

C_2 = Concentration of the compound or element in the duplicate

For this test plan the entire flow for a 24-hour period will be collected as the sample for delivery to the laboratory. Therefore, there will not be field duplicates collected as there will only be one entire sample and there will be no issue with variation between samples taken on a given day. The laboratory will run duplicate samples after the sample is settled by splitting selected samples and running duplicates. Spiked duplicates will also be run as part of the analytical procedures. Both settled sample duplicates and analytical duplicates will be run once for every ten samples collected or analyzed. The data quality objective for precision based on the mercury analysis is $\pm$ 20% for liquid samples and $\pm$ 35% for solid samples.

7.1.2 Accuracy

Accuracy is defined for water quality analyses as the difference between the measured value or calculated sample value and the true value of the sample. Spiking a sample matrix with a known amount of a constituent, in this case mercury, and measuring the recovery obtained in the analysis is a method of determining accuracy. Using laboratory performance samples with a known concentration in a specific matrix can also monitor the accuracy of an analytical method for measuring a constituent in a given matrix. Accuracy is usually expressed as the percent recovery of a compound from a sample. The following equation will be used to calculate Percent Recovery:

$$\text{Percent Recovery} = [(A_T - A_i) / A_s] \times 100\%$$

Where:

A_T = Total amount measured in the spiked sample

A_i = Amount measured in the un-spiked sample

A_s = Spiked amount added to the sample

During the VTP analyses the laboratory will run matrix spike and matrix spike duplicate samples for the mercury analyses for solid and liquid samples. The laboratory will also analyze a liquid and solid sample of known mercury concentration as a lab control sample. The data quality objective for accuracy will be recoveries in the range of 80% - 120% for liquid samples and 75% – 125% for solid matrices.

7.1.3 Comparability

Comparability will be achieved by using consistent and standardized sampling and analytical methods. All analyses will be performed using USEPA published methods as listed in the analytical section. Any deviations from these methods will be fully described and reported as part of the QA report for the data. Comparability will also be achieved by using National Institute of Standards (NIST) traceable standards including the use of traceable measuring devices for volume and weight. All standards used in the analytical testing will be traceable to verified standards through the purchase of verifiable standards and maintaining a standards logbook for all dilutions and preparation of working standards.

Comparability will be monitored through QA/QC audits and review of the test procedures used and the traceability of all reference materials used in the laboratory.

7.1.4 Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic population, parameter at a sampling point, a process condition, or an environmental condition. The test plan design calls for the entire influent or effluent to be collected as the sample for delivery to the laboratory. Therefore, the sample will be representative of the wastewater at this facility. The laboratory will follow set procedures (as described in the SOP's and in accordance with good laboratory practice) for thorough mixing of any samples prior to sub-sampling in order to ensure that samples are homogenous and representative of the whole sample. The site for this test has been selected and reviewed to determine that it is representative of a typical dental office for which the treatment technology has been designed. The MRU will be operated in a manner consistent with vendor supplied O&M manual so that the operating conditions will be representative of a normal installation and operation for this equipment.

Representativeness will be monitored through QA/QC audits (both field and laboratory), including review of the laboratory procedures for sampling handling and storage, review and observation of the sample collection, and review of the operating logs maintained at the test site.

7.1.5 Completeness

Completeness is a measure of the number of valid samples and measurements that are obtained during a test period. Completeness will be measured by tracking the number of valid data results against the specified requirements in the test plan.

Completeness will be calculated by the following equation:

$$\text{Percent Completeness} = (V / T) \times 100\%$$

Where:

V = number of measurements that are valid
T = total number of measurements planned in the test

The goal for this data quality objective will be to achieve 90% completeness for each parameter and sample group scheduled in the test plan.

7.2 PROJECT MANAGEMENT

7.2.1 Management Team

The Test Organization is responsible for management of the VTP including meeting the VTP objectives and the Data Quality Objectives. Section 3 of the VTP describes the key personnel involved in this ETV program and the persons responsible to implement the test plan, including a Quality Control Officer from NSF who will be responsible for audits, assessment, and review of procedures and quality data. The phone number, email address, and mailing address for each person named are given in Section 3.

The Testing Organization (TO) for the verification testing is a consortium of NSF International, Inc., Scherger Associates, and Mr. Adam Markie. This group was organized by NSF to bring together resources that can complete a high quality verification test program in a cost effective manner. Each participant in the consortium has a well-defined role in planning and executing the verification test plan.

Mr. Dale Scherger of Scherger Associates is the Project Manager (TO) and is responsible for development of the verification test plan (VTP) for the TO, obtaining all of the information needed to plan and execute the VTP, managing the data collected during the test period, preparing the draft final report, and providing technical guidance in conjunction with the Technology Panel. Mr. Adam Markie will provide field support at the test site, including setup and operation of the MRU, collection of the daily and weekly records from the dental office, and collection and shipment of the samples on a daily basis. Mr. Markie will provide any maintenance support required during the verification test period in consultation with the vendor, DRNA.

NSF International will provide the laboratory services for the testing program and will provide consultation and implementation on any sampling and analytical issues that need to be addressed throughout the verification test period. NSF will be responsible for all quality assurance for the VTP through its QA group. NSF will provide administrative and technical support for review and production of the VTP and the Final Report. NSF will also handle project management and

cost tracking support for this VTP. The NSF staff involved in the VTP (the NSF Laboratory and assigned laboratory QA/QC staff) will be separate from the NSF management and staff (members of the Verification Organization team) that are providing the oversight for the ETV program.

The responsibilities of the TO consortium include:

- Preparation of the site specific Verification Test Plan;
- Conducting Verification Testing, according to the Verification Test Plan;
- Installation, operation, and maintenance of the MRU in accordance with the Vendor's O&M manual(s);
- Controlling access to the area where verification testing is being carried out;
- Maintaining safe conditions at the test site for the health and safety of all personnel involved with verification testing;
- Scheduling and coordinating all the activities of all verification testing participants, including establishing a communication network and providing logistical and technical support on an "as needed" basis;
- Resolve any quality concerns that may be encountered and report all findings to the Verification Organization;
- Managing, evaluating, interpreting and reporting on data generated by verification testing;
- Evaluation and reporting on the performance of the technology; and,
- If necessary, document changes in plans for testing and analysis, and notify the Verification Organization of any and all such changes before changes are executed.

The key personnel and contacts for the TO are:

Mr. Dale Scherger, Project Manager (TO)
(704)-947-7050 email: daleres@aol.com

Mr. Adam Markie – Field Operations and sampling
(810) 727-4115 (home) (810) 727-7980 (work)

Mr. Steve Williams, NSF International – Laboratory Support
Phone number: (734) 769-5357 email: williams@nsf.org

Bruce DeMaine, Manager, QA and Safety
NSF International - Quality Assurance Support
734-769-5143 email: demaine@nsf.org

Note: Mr. DeMaine may appoint a designee for some of the QA tasks.

Key contacts for the Verification Organization are:

Mr. Thomas Stevens, Program Manager (VO)
(734) 769-5347 email: Stevenst@NSF.org

Ms. Maren Roush, Project Coordinator (VO)
(734) 827-6821 email: MRoush@NSF.org

7.2.2 Project Description and Objectives

A full description of the project history, the DRNA MRU technology being verified, and objectives has been presented in Sections 1 through 4 of the VTP. A brief summary of the project is presented herein. The reader is referred to the VTP for more details.

Dental office wastewater often contains mercury amalgam and some soluble mercury due to the removal and placement of mercury amalgams as part of general dentistry practice. This mercury is normally discharged to the building sewer system where it can enter the environment through publicly owned wastewater treatment plant discharge, through septic tank system discharges, or via sludge produced by these systems which tends to concentrate the mercury. Dental Recycling North America has developed a mercury treatment system, the Mercury Removal Unit (MRU) to remove mercury from dental office vacuum systems before the mercury enters the sewer system. The MRU uses a combination of settling technology (the BullfroHg separator), a particle filter, and an adsorbent filter to remove both mercury amalgam and soluble mercury. The captured mercury remains in the MRU separator, particle filter and adsorbent until they are returned to DRNA for reclamation.

The primary objective of the ETV is to measure the performance of these technologies for the removal of mercury in real world applications through a well-defined test plan that includes measurement of mercury (insoluble and soluble) in the wastewater before and after application of the treatment technology.

This objective will be accomplished by implementing the sampling and analysis program described in Sections 5 and 6 and by meeting the data quality objectives described in this Quality Assurance Project Plan. The test plan includes characterizing the wastewater at the site, installing and operating the MRU, and measuring the effluent from the MRU and all residuals removed and contained within the MRU. The primary parameter being measured is mercury. Other parameters will include volume and weight measurements of the samples and residuals, and pH. A special settling test is also part of the sample preparation procedures. A full set of

documentation describing the procedures and documenting the results will provide the basis for completion of the Verification Report.

7.2.3 Project Schedule

The project schedule for this work is presented in Section 2.6 and is summarized below.

Week One -	Install characterization sample collection container in vacuum system Disconnect and by-pass the DRNA Particle Traps at each chair Test the collection system
Week Two	Begin characterization sample collection - 4 days of sampling
Weeks Three Seven	Continue collecting characterization samples 4 days/week for 5 weeks = 20 samples
Week Eight	At the end of the last sample day- flush the system with flushing solution using the normal protocol Collect last characterization sample – 1 sample Review the characterization data to insure that the dental system and the record keeping meet the objectives and needs of the verification test. Obtain approval for the Verification Organization, NSF to proceed with the verification test.
Week Nine	Once approval to proceed with the verification in obtain begin to install a new DRNA MRU unit in the vacuum system. (Note: if approval to proceed is obtained at the beginning of Week Eight, installation can proceed earlier.) Place discharge tube from the MRU into a sample bottle and test the system. Run the entire system with clean water for a period of time to verify all is working correctly. The flush water collected in the sample bottle will be sent to the laboratory as a normal sample for mercury analysis. (Verification sampling may be able to begin this week if the MRU is installed, checked and ready for operation, and the characterization review by the VO is complete.)
Week Ten	Begin Verification Testing – Collect daily samples for 4 operating days

Week Eleven To Fifteen	Continue collecting characterization samples 4 days/week for 5 weeks = 20 samples
Week Sixteen	At the end of the last operating day, thoroughly flush the system with flushing solution. Collect last verification test sample – 1 sample Remove the BullfroHg settling container from the MRU system and send to the laboratory for residue removal. Remove the particle filter and adsorbent filter units and send to the laboratory for analysis of residues and the adsorbent. The particle filter and adsorbent will be analyzed separately. Restore all parts of the vacuum system to the original condition prior to the test. Install new MRU parts (BullfroHg, particle filter and adsorbent filter) and re-install the DRNA Particle Traps at each chair location.
Weeks Seventeen To Nineteen	Complete the laboratory analysis of all samples.

7.3 MEASUREMENTS AND DATA ACQUISITION

7.3.1 Sample Collection and Chain of Custody

Samples of the untreated wastewater will be collected in a dedicated sample bottle installed in the vacuum system. The entire flow from a 24-hour period will be collected in the sample bottle and sent to the laboratory for analysis. Following completion of the characterization work (collection of 25 samples), the MRU will be installed and placed in operation. The MRU separator collects all the water from a full day of vacuum system operation. At the end of the day the solids are allowed to settle in the separator for several hours. The wastewater will then be pumped at a set flow rate through the fine particulate filter and the adsorbent filter. The tubing carrying the effluent from the adsorbent filter is secured in the 10-liter sample container. The entire flow for a 24-hour period will be collected in the sample bottle. At the end of each sampling period, the sample bottle will be returned to the laboratory for volume measurement and chemical analysis. More details on the sample collection procedures are given in Section 5.

The sample bottles will be 10-liter vacuum-rated polypropylene containers that have been cleaned in accordance with the cleaning procedure presented in Section 5 and Appendix B. The laboratory will be responsible for all cleaning and return of the sample containers. At the beginning of the test, a sample bottle will be filled with six liters of water containing 500 ug/l of mercury. The bottle will sit over night and then be emptied of the mercury solution. The bottle will then be cleaned using the standard procedures. This clean bottle will be filled with six liters of mercury free water (<0.2 ug/l) and allowed to sit overnight. The “blank” water will then be

analyzed for mercury to demonstrate that the cleaning procedure is effective in removing mercury from the bottle. A minimum of two additional bottle blanks will be prepared and analyzed during each of the two testing periods. Mercury free water (<0.2 ug/L) will be placed in a cleaned bottle and will be stored overnight. The blank will be run as a regular sample for mercury analysis.

All samples collected will be labelled with a unique number that will identify the sample location, sample type, and date of sample. All bottles will be capped tightly after removal from the sampling location and will be sealed with custody tape. The sampler will initial and date the seal. A chain of custody form (supplied by the laboratory) will be filled out and accompany all samples. The custody form will include the sample identifier, the parameters for analysis, the date, and the signature of the sampler. The bottle will be cooled in ice and shipped with ice to maintain a cool temperature during transport to the laboratory. A record of the time, date, and sample number(s) will be recorded in the on-site logbook.

7.3.2 Analytical Methods

All of the analytical methods used for the measurement of mercury (total and soluble) and pH will be performed using USEPA approved methods. All volume and weight measurements will be performed using good laboratory practice and with equipment (balances, etc.) that are calibrated with NIST traceable standards. Table 7-1 shows the parameters and test methods that will be used for this verification test plan. Additional information on the various sample types is given in Sections 5 and 6. The laboratory standard operating procedures (SOP) for mercury and pH are presented in Appendix B. Any deviations from these methods must be documented and the QA Officer notified immediately.

The influent and effluent samples will be logged in upon receipt at the laboratory. All of these samples require a special settling procedure to separate the settleable solids from the liquid sample. The settling procedure has been documented in the SOP given in Appendix B. The samples will be measured for volume and placed in the settling tank within four hours of receipt. If for some reason the procedure cannot begin within that timeframe, the samples will be stored under refrigeration until the settling process can be started. Samples should be processed as soon as possible. After the settling procedure the liquid will be decanted from the tank and placed in a new sample container. This liquid will be analyzed for both total and soluble mercury. The solid material settled in the tank will be placed in a separate sample container and will be weighed and the volume determined. Representative sub samples (collected in triplicate) will be analyzed for total mercury.

Table 7-1. Analytical Methods and Detection Limits

Sample Matrix	Analyses	Reference Methods	Detection Limit
LIQUID	pH Mercury (Total) Mercury (Soluble) Mercury (TCLP)	150.1 7470A/245.1 7470A/245.1 7470A/245.1	N/A (range 1-13 S.U.) 0.2 ug/L 0.2 ug/L 0.2 ug/L
SOLID	Mercury (Total) TCLP	7471A/245.5 1311	0.25 mg/kg N/A

The analytical method and recovery for the adsorbent material will need to be verified prior to testing the adsorbent at the end of the verification test. The vendor will supply isotherm data for the adsorbent to be used in finalizing this test procedure. A known amount of mercury in solution will be placed in a flask and a known amount of adsorbent added to the flask. The material will be stirred for a minimum of 4 hours to allow the adsorbent to remove mercury from solution. The adsorbent will then be separated from the water by filtration through a glass fiber filter. The adsorbent and the liquid will be analyzed for mercury. The difference between the original mercury mass in the liquid and the remaining mass in the liquid will determine the amount that was adsorbed. The results of the adsorbent analysis will then show the amount of mercury measured on the adsorbent. The recovery efficiency for mercury in the adsorbent will be determined by the equation:

$$\text{Percent recovery} = [M_A / (M_I - M_F)] \text{ X } 100$$

Where:

M_A = Mass measured in the adsorbent

M_I = Mass in the initial liquid

M_F = Mass in the liquid after adsorption

7.3.3. Analytical Quality Control

The quality control procedures for blanks, spikes, duplicates, calibration of equipment, standards, reference check samples and other quality control measurements will follow the guidance in the

USEPA methods, the NSF SOP's and the NSF Quality Assurance and Quality Control Manual. Table 7-2 shows the frequency of analysis of these various quality control checks. Table 7-3 shows the quality control limits that will be used by the laboratory for these analyses and to ensure compliance with the DQI for accuracy and precision. Accuracy and precision will be calculated for all data using the equations presented in section 7.1.

Table 7-2. Summary of Calibration Frequency and Criteria

Analysis (Reference Methods)	Calibration Frequency	Calibration Points	Acceptance Criteria
pH (150.1)	Check calibration after every 5 non-calibration analyses	Initial Calibration: Two buffers 4-7 or 7-10 Independent buffer at 7 (ICV) Continuing Calibration Check: Alternate pH 7 and 10 (CCV) Or pH 4 and 7 (CCV) Depending on initial calibration range	Initial: ICV $\pm$ 0.1 s.u. Continuing: CCV $\pm$ 0.1 s.u.
Mercury (7470A, 7471A) (245.1,245.5)	Check calibration after every 10 non-calibration analyses	Initial Calibration: 5 standards and blank (ICB) low- to mid-range standard from alternative source (ICV standard) blank (ICB blank) Continuing Calibration Check: low- to mid-range standard from alternative source (ICV standard) blank (ICB blank)	Initial: Correl. Coeff. $\geq$0.995 ICV $\pm$10% of Theo. Value ICB <0.2 ug/L Continuing: CCV $\pm$10% of Theo. Value CCB <0.2 ug/L

Table 7-3. Summary of Analytical Accuracy and Precision Limits

Analysis (Reference Methods)	Precision	Accuracy	Detection Limit
Mercury Liquids (7470A, 245.1))	20%	80-120%	0.2 ug/L
Mercury Solids (7471A, 245.5)	35%	75-125%	0.25 mg/kg
pH (150.1)	N/A	N/A	N/A

N/A - Not applicable

Blank water used for all laboratory mercury analysis and water used for final bottle rinsing must be shown to be mercury free (<0.2 ug/L). If mercury contamination is detected in the blank water, the analysis must be stopped and the problem corrected. Laboratory blanks, method blanks and any other blank water data must be reported with all analytical results.

Laboratory control samples will be used to verify the mercury methods are performing properly. The water control samples will be blank water spiked with mercury from a mercury standard obtained from certified source material different from the standard solutions being used for calibration. A solid control sample will be analyzed using a solid matrix material with a known amount of mercury. Both lab control samples will be carried through the entire analysis including the digestion step in the case of the solid matrix.

Calibration of the pH meter will follow standard practice as given in the SOP. The instrument will be calibrated using a two-point calibration with certified pH buffer solutions. The calibrated pH range (typically pH 4-7 or pH 7-10) will be selected based on the expected pH of the samples. Calibration is verified using an independent buffer solution in the calibrated range.

Calibration for the mercury analysis will be based on a minimum three-point calibration curve in the linear range of the method and instrument as detailed in the SOP. The calibration sequence includes a method blank, five point calibration, a standard check sample prepared from a secondary source, which must be within $\pm$ 10% of the true value. The calibration is checked after each group of ten samples. If the calibration check results fall outside the acceptance criteria, the instrument is recalibrated and the affected samples are analyzed again.

Balances are calibrated each day with NIST traceable weights. A calibration logbook is maintained to demonstrate the balances are accurate.

7.3.4 Data Reduction, Handling and Reporting

7.3.4.1 Reporting Requirements

Table 7-4 shows the reporting requirements for all chemical and physical measurements.

Table 7-4 Reporting Requirements for Physical and Chemical Measurements

Analysis/Measurement	Units
Total Sample weight – All solid samples or settled residuals	grams
Total Sample volume – All liquid and liquid/solid samples delivered to or split in the laboratory	mL
pH	s.u.
Mercury – All forms measures -liquid	ug/L
Mercury - Solid concentration Solid mass	mg/kg mg
Total flow by calculation	L/day

7.3.4.2 Documentation

All of the field and laboratory activities will be thoroughly documented by the use of field logbooks, chain of custody sheets, laboratory notebooks and bench sheets, and instrument records.

A field logbook will be maintained at the site. Daily activity entries will be made in the logbook documenting operating conditions, observations, and maintenance activities, if any are needed. Each sample collected will be noted in the logbook, giving the time of sample collection and replacement of the sample container, notation that the dental office log was collected and sent with the sample(s) to the laboratory and any other pertinent information. Completed pages in the logbook will be signed and dated. Copies of the logbook pages will be forwarded to the Project Manager (TO) for review each week. The dental office staff will also maintain a dental office log. The number of amalgams removed and placed will be logged with information on the tooth

number that was treated. The time and quantities of flushing fluid used by chair number will also be written on the log. A copy of the daily dental office log will be sent with the chain of custody sheet each time a sample is sent to the laboratory. The laboratory will forward a copy of the dental office log and the chain of custody to the Project Manager (TO).

Original chain of custody forms will be sent with all sample(s) sent to the laboratory. The laboratory will maintain the original chain of custody until the end of the analysis and then attach the original to the final data report sent to the Project Manager (TO). The laboratory will produce a final data report that includes all chemical test results, physical measurements, QA/QC data for blanks, accuracy (recovery), and precision (percent difference), and lab control or matrix check samples. Any deviations from the standard protocols will be discussed in a narrative and any data that does not meet the QA/QC requirements will be flagged and a narrative prepared discussing the findings of any corrective action.

The laboratory will maintain all logbooks, bench sheets, instrument printouts etc. in accordance with the NSF laboratory QA/QC Manual. The QA/QC or Laboratory Coordinator will make these records available for inspection upon request.

7.3.4.3 Document Handling

During the test period the original field logbook will be kept at the test site. Copies will be sent weekly to the Project Manager (TO) to be maintained in a secure file location. At the end of the test period the original logbook will be sent to NSF for storage in a secure central project file. Dental office logs sent to the laboratory will be copied with the chain of custody sheets and these copies will be sent to the Project Manager (TO). The original dental office logs will be maintained at a central file at NSF. Original laboratory data reports with the original chain of custody will be placed in the central project file at NSF Copies of these reports and any electronic data will be sent to the Project Manager (TO) and QA/QC officer for review. Other copies of the data or logbooks may be distributed to other project team members.

7.3.4.4 Data Reduction and Validation

All measurements and analytical results will be reported in units that are consistent with the methods used and as shown in Table 7-4. The laboratory analysts will record raw data in laboratory notebooks or bench sheets using standard formats. Each analytical method will contain instructions for recording and calculating the results. The laboratory analyst will have primary responsibility to verify the results recorded are accurate. Data review and QA/QC review will be the responsibility of the NSF laboratory staff following the NSF standard data review and verification procedures for the laboratory. Data transcribed for entry to a computerized database will be checked against the lab bench sheets or instrument printouts by a second person. The same procedure will be followed for any electronic reporting of data, such as the Excel spreadsheet that is required for final data submittal. The final data report will be signed by an authorized laboratory manager/supervisor in accordance with laboratory policy.

The final data reports and electronic data received by the project team (the TO team of NSF laboratory assigned staff and Mr. Scherger) from the laboratory will be 100% checked. The Project Manager (TO) or designee will cross check 100% of the data in the final reports from the laboratory with a printout of the spreadsheet provided by the laboratory. The QA/QC officer for the VO (NSF ETV Program) will review the final data reports and all QA/QC information. The QA/QC officer will issue a QA/QC review report discussing the quality of the data, how it compares to the Data Quality Objectives, and any data that should be flagged as invalid or questionable. The VO Project Coordinator will back check 100 % of the draft verification report data tables and calculations with the laboratory data and spreadsheets provided by the TO.

7.4 ASSESSMENTS

The project QA/QC officer (assigned to the TO) or a designee will be responsible for making announced and unannounced field and laboratory audits to observe adherence to the cleaning/operational protocols, sample collection methodology, sampling handling practices, and analytical procedures detailed in the VTP. The QA/QC Officer will review logbooks and final data reports to ensure that these records meet the DQI requirements and other requirements for the VTP. The Project Manager (TO) and the QA/QC Officer (part of the TO team) will validate data, as it is received from the laboratory.

The NSF laboratory has an assessment program that includes internal and external audits, Quality reports to management, and other internal checks are part the system used to ensure the NSF QA/QC procedures are being implemented and maintained. The NSF assessment procedures will be part of the QA/QC program and will be followed during the time the analytical work is being performed for the verification test.

At least two field audits will be conducted by the VO (NSF ETV Program QA/QC staff or Project Coordinator VO) during the characterization test, and at least two field audits will be conducted during the verification tests. These audits will be to observe the sample collection procedures being used, to observe operation of the MRU, condition of the test site, and to review the field logbook(s). A written report will be prepared by the auditor and submitted to the QA/QC Officer and the Project Coordinator. At least one lab audit will be performed during the characterization test to observe sample receipt, handling, storage, and to confirm proper analytical methods, QA/QC procedures and calibrations are being used. Special attention will be paid to observing the sampling handling, settling procedure, and bottle-cleaning procedures during the audit(s).

7.5 CORRECTIVE ACTION

Field related activities that could require corrective action include, problems with sample collection, labelling, or shipping, improper entries or missed entries in logbooks, or operational problems with the MRU. The primary person responsible for monitoring these activities will be

Adam Markie with audits by the NSF designated staff. If a problem occurs, the problem will be noted in the field logbook and Mr. Markie will notify the Project Manager (TO) in all cases and the vendor in the case of MRU operating issues. The problem, once identified will be corrected. If a change in field protocol related to sample collection or handling is needed, the change will be approved by the NSF ETV Project Manager. All corrective action required will be thoroughly documented and discussed in the Verification Report.

Laboratory corrective action will be taken; whenever there is a non-conformance with sample receiving or handling procedures; whenever the QA/QC data indicates any analysis is out of the established control limits; whenever audit findings indicate a problem has occurred; and whenever data reporting or calculations are determined to be incorrect. The NSF laboratory has a formal corrective action plan as part of the laboratory QA/QC Manual. These procedures will be followed including notifying the laboratory QA/QC Manager and the Test Organization QA/QC Officer. All corrective action will be thoroughly documented and reported to the Test Organization. All data impacted by a correction will be so noted and a discussion of the problem and corrective action will be included with the data report.

All corrective actions, either in the field or in the laboratory, will be reported to the Verification Organization (VO) Project Coordinator within twenty-four hours of the problem occurring. The VO will review the cause of the problem and the corrective action taken by the TO. The review will include consideration of the impact of the problem on the integrity of the test and make a determination if the test can continue or if additional action is needed. Additional action could include adding additional days top the test period, re-starting the test at day one, or other appropriate action as determined by the VO. The VO will respond to any notification of corrective action within twenty-four hours of being notified of the problem. This response can be to continue the testing, cease testing until further notice, or other appropriate communication regarding the problem. The response by the VO will be in writing either by email, fax, or letter.

8.0 DATA MANAGEMENT AND ANALYSIS

Several types of data will be collected or generated during the testing periods of this VTP. Quantitative data, including flow data, influent and effluent water quality data, type and amount of residuals generated, etc., will be measured and reported by the laboratory. Qualitative data describing the setup, operation, and maintenance of the MRU will collected in the field throughout the test period. All of this information will be managed during the verification using methods outlined in this section. The test results will be analyzed and presented in the verification report using a standardized approach, which is described in Section 8.3.

8.1 DATA MANAGEMENT

The data being collected during this verification will include both manual and electronic data collection and storage methods. Field and laboratory notebooks will be maintained to document all activities related to the sampling, operation, and maintenance activities at the site, and to document sample handling, equipment calibrations, and other related activities in the laboratory. Laboratory results will be reported in paper reports showing all of results and QA findings for each set of data. These results will then be entered into Excel spreadsheets for ease of analysis and storage.

All samples collected in the field or prepared in the laboratory will be assigned a specific identification number that will be used to track and record the data throughout the collection, analysis, and data reporting steps. The numbering system will include the use of an identifier for the test phase associated with the sample (characterization or verification), an identifier of sample type (solid, liquid, residual), sample location (influent, effluent) and the date of collection. The field sampling personnel will assign the sample number for all samples collected on-site. The samples collected in the field will have a clear label with the sample number and date on the label. The chain of custody sheet accompanying the sample(s) to the laboratory will also show this sample identification number. The laboratory will also be generating samples and sub-samples during the test. Samples received from the field will be settled and divided into two samples for analysis, and the liquid decanted from the settling tank will be divided between a filtered and unfiltered sample. The laboratory will assign unique identification numbers to these sub-samples that will clearly identify their nature and will tie back directly to the sample identification assigned in the field. The laboratory data reports will show the sample identification numbers and will include copies of the chain of custody forms that clearly track the sample names from their assignment in the field through the analysis in the laboratory.

8.1.1 Manual Data Collection

All data collection, observations, and sample records will be written in a field logbook maintained at the site by field personnel. This logbook will have carbon copies that will be removed and forwarded to the Project Manager (TO), Dale Scherger, on a weekly basis. In addition, the dental office will maintain a daily log on prepared log sheets documenting office procedures, including the number of amalgams removed and replaced, any flushing of the vacuum lines, and other related information. Each day a copy of the dental log will be obtained

by the field staff and forwarded with the sample(s) and chain of custody to NSF. Copies of these records will then be reviewed by the Project Manager (TO) or a designee to ensure the records are being properly maintained. At the end of the verification test, the field log book and the original dental office logs will be sent to the NSF offices and will become part of the permanent record for this verification test.

The laboratory will use laboratory notebooks to record all manual data and related information in accordance with good laboratory practice and the laboratory QA/QC and SOP documents. The laboratory logbooks will be available for review by the Quality Assurance Officer or Project Coordinator at any time. The laboratory will be responsible for maintaining and archiving the notebooks and manual records that support the data reported by the laboratory. The original chain of custody records and any appropriate supporting documents will be provided with the data reports. The data reports will include a discussion of any problems that occurred during the analysis, corrective action taken, and any other factors that could impact the data. The laboratory reports will include all QA/QC results, including blanks, spikes, duplicates, check samples, etc., such that the Quality Control Officer can validate the data and make an independent opinion as to the quality and acceptability of the data.

8.1.2 Electronic Data Collection

The laboratory will provide the sample volume information (for determining daily flow), residuals weight and volumes (for mass balances) and the analytical results in both hard copy reports and in electronic format. The data will be entered into an Excel spreadsheet in a format that will be finalized and provided by the laboratory coordinator. The laboratory will verify the data in the spreadsheet by comparing a print out of the spreadsheet with the hard copy results and their supporting documents prior to release of the data.

Upon receipt of the laboratory reports and spreadsheets, the Project Manager (TO), QA Officer or their designee will verify the accuracy of the data. A direct comparison of the hard copy data and the electronic spreadsheet will be made. Any corrections required will be written on the print out of the spreadsheet and the corrections made to the spreadsheet. An electronic log will be maintained as part of the spreadsheet (using a worksheet within a workbook) to record the review date, corrections needed, reviewer's initials and other pertinent information about the review and audit of the spreadsheet. A paper log will also be maintained showing the date(s) the review occurred, the reviewer's initials, name of the spreadsheet or data set, and any corrections needed. This paper log can be a printout of the electronic audit/review log that is signed and dated by the reviewer. If corrections are needed, the laboratory will be sent a revised copy of the spreadsheet so that they can maintain a current corrected copy as well.

At least two copies of the electronic data will be maintained at all times, in addition to the laboratory copy maintained at the lab. One copy will be on the Project Manager (TO) or designee's hard drive and one copy will be maintained on floppy disk. At the end of the project a floppy disk copy of the final spreadsheets will be stored with the laboratory records in the project archives.

8.2 DATA ANALYSIS AND PRESENTATION

All results, including statistical analysis, will be provided in the Verification Report. Any data that was excluded in statistical analysis will be reported with an explanation as to why it was not included in the analysis. The data obtained during influent characterization and verification testing will be statistically analyzed, reduced, and presented in tables, graphs and charts. All raw data will be included as an appendix to the Verification Report. The statistical methods and any statistical programs used will be described in the Verification Report. A detailed discussion of the results will accompany the tables, graphs and/or charts and shall be presented in the Verification Report (see Section 8.3). Conclusions drawn from the analysis of the test results will be presented in the Verification Report.

8.2.1 Flow Data

Flow data will be obtained during the influent characterization and verification testing periods by determining the total volume of sample collected for each 24-hour period. The entire flow from the vacuum system is being collected directly into the sample bottle. The results will be presented as follows:

- A graph showing daily flows; the date, and sample number corresponding to the data presented shall be shown on the graph, as applicable; and,
- A table showing average, maximum and minimum daily flow, and 95% confidence interval.

8.2.2 Treatment Performance Quality Data

Valid wastewater quality data for mercury (various forms, settleable, soluble, insoluble where applicable) obtained during the influent characterization and verification testing periods will be analyzed and presented as follows:

- Graph showing the daily influent sampling results for total mercury;
- Table showing the average, maximum and minimum influent concentration for the sampling events and the 95% confidence interval for total mercury;
- Graphs showing the daily effluent sampling results obtained for settleable mercury, soluble mercury and total mercury after settling;
- Tables showing the average, maximum and minimum effluent concentration for the sampling events and the 95% confidence interval for settleable mercury, soluble mercury and total mercury after settling;
- Table showing the mass of mercury in the residual stream; and
- Tables showing the average removal efficiency and the 95% confidence limit for total mercury and soluble mercury.

8.2.3 Operation and Maintenance Parameters

Results of monitoring operation and maintenance parameters during verification testing shall be presented in a discussion format. The Verification Report will include a thorough discussion of any difficulties encountered in operating or maintaining the MRU during the verification test. Discussion will include observations regarding the ease/difficulty of installation, and also factors, such as operator training, presentation clarity in the O&M manual, etc.

8.2.4 Equations

The data analysis will include the calculations of removal efficiency and various statistics. The equations to be used in the data analysis are provided below.

Removal Efficiency (as percent)

$$= \frac{\text{(mg Hg captured in MRU)}}{\text{(mg Hg capt'ed in MRU. + mg Hg in Samples* taken after the MRU)}} \times 100$$

* Samples are settled prior to analysis, resulting in a liquid component and a solids component. Therefore, data for each sample will include a mass for the liquid component (mg/l X liters) and a mass for the solids component.

Sample Mean (Average)

$$y_{bar} = \Sigma v / n$$

Where:

y_{bar} is the sample mean

Σv is the sum of the sample values

n is the number of samples

Standard Deviation

$$s = (\Sigma (y - y_{bar})^2 / n)^{1/2}$$

Where:

s is the sample standard deviation

y is an individual sample value

y_{bar} is the sample mean

95% Confidence Interval $= y_{bar} \pm t_{\alpha/2} (s / n^{1/2})$

Where:

y_{bar} is the sample mean

s is the sample standard deviation

n is the number of samples

$t_{\alpha/2}$ is the Student's t-distribution with n-1 degrees of freedom, with $\alpha/2=0.025$

and

$t_{\alpha/2}$ = 2.068 for n=25

Refer to statistical references for other values.

8.3 Verification Report

The Verification Report will be a document containing all raw and analyzed data, all QA/QC data sheets, a description of all types of data collected, a detailed description of the testing procedure and methods, results and QA/QC results. The Report will thoroughly present and discuss the findings of the verification test. Conclusions regarding the performance of the MRU will be made and compared with the performance goals for the verification test.

It is expected that the Verification Report will contain the following main sections. There may be some deviation from the order given below in order to present the findings in a clear and precise manner. Additional sections will added as needed to properly present all of the findings

- Preface
- Glossary
- Acknowledgements
- Executive Summary
- Introduction and Background
- Procedures and Methods Used In Testing (summarizing essential information from the Test Plan)
- Results and Discussion
- Limitations
- Conclusions
- Recommendations
- References
- Appendices

  Raw Data

Special Laboratory Procedures – Standard Operating Procedures
QA/QC Manual/Procedures
MRU O&M Manual
Field logs and supporting documentation as appropriate

9.0 HEALTH AND SAFETY PLAN

The testing site is at a dental office in Michigan. The dry vacuum system has been installed in accordance with local plumbing and electrical codes. The vacuum system is located in a utility room with ventilation. There will be no need for any confined space entry and all equipment is readily accessible at ground level.

The installation of the sample bottle and MRU will be performed using standard plastic tubing connectors and the system will be checked for vacuum leaks after installation. The installation will follow all plumbing code requirements. Electrical connections are only 120 volt AC and apply only to a small tubing pump and a timer. Total power requirement is 4 amp, 120 VAC. The equipment comes prewired with a standard grounded 110 VAC plug. The cord will be plugged into the electrical outlet in the utility room.

Cleaning solutions are commercially purchased trade name materials – Pure VAC. The MSDS sheet for this material is in Appendix D and will be available at the site. First aid instructions are provided in the MSDS sheet. The dentist office staff will perform all line flushing. The staff is trained and familiar with the chemicals and procedures. The DRNA MRU only uses one chemical- household bleach – which is made into a solution and stored with the unit. Protective glasses, normal clothing, and latex gloves will be used when making the solution and changing the solution feed bottle.

Samples are collected in dedicated sample bottles that are either installed in the vacuum line for the characterization test or are at the end of the sample line from the MRU. The entire sample bottle and its contents will be sealed and transported to the laboratory so there should not be any contact between the sampler and the wastewater. However, the wastewater is water that can contain human secretions and blood, and therefore needs to be handled as a potential biohazard. The sampling technician will wear latex gloves and eye protection whenever the sample bottle is being replaced or handled in anyway. The bottle will be sealed and placed in a cooler for transport to the laboratory.

Any time sample bottle handling is occurring two people (TO sampling person and one representative of the dentist office) will be present in case of any sample spillage or other accident should occur. If sample is spilled or in anyway contacts a person, the affected individual will immediately wash the material off the gloves, clothing, or other articles or skin that were in contact with the wastewater using disinfectant soap and large amounts of water. After the individual involved in the spill has thoroughly cleaned themselves or have been cleaned by the standby safety person, the remaining area in the room will be thoroughly cleaned using disinfectant soap and/or bleach. The spill of material will be logged and the Project Manager (TO) and the Project Coordinator (VO) will be contacted.

A one page emergency contact sheet will be at the sampling site. This sheet will show the closest hospital, have emergency contact phone numbers for the local area, and will have the phone number of the site owner and Dale Scherger, the Project Manager (TO). NSF phone numbers will also be shown.

The laboratory will follow the NSF Laboratory Health and Safety Plan. All members of the NSF laboratory have been trained in the proper Health and Safety procedures for laboratory operations and sample handling.

As stated in the sampling and analysis plan, mercury residues and samples will be disposed of using the NSF laboratory guidance for safe sample disposal or will be sent to DRNA for mercury recycling. Solids from the chair side traps will be sent to for reclamation to DRNA. Any solid residues remaining after analysis is complete will either be sent for reclamation or disposed of with other similar laboratory waste. Liquid samples that have been acidified will be handled in accordance with NSF policy.

10.0 REFERENCES

(1) NSF International, *Protocol for the Verification of Mercury Amalgam Removal Technologies*, 2000, Ann Arbor, Michigan.

(2) United States Environmental Protection Agency: *Environmental Technology Verification Program - Quality and Management Plan for the Pilot Period (1995 – 2000)*, USEPA/600/R-98/064, 1998. Office of Research and Development, Cincinnati, Ohio.

(3) NSF International, *Environmental Technology Verification – Source Water Protection Technologies Pilot Quality Management Plan*, 2000. Ann Arbor, Michigan.

(4) United States Environmental Protection Agency: *Methods and Guidance for Analysis of Water*, EPA 821-C-99-008, 1999. Office of Water, Washington, DC.

(5) APHA, AWWA, and WEF: *Standard Methods for the Examination of Water and Wastewater, 20th Edition*, 1998. Washington, DC.

(6) United States Environmental Protection Agency: *USEPA Guidance for Quality Assurance Project Plans, USEPA QA/G-5*, USEPA/600/R-98-018, 1998. Office of Research and Development, Washington, DC.

(7) United States Environmental Protection Agency, *Guidance for the Data Quality Objectives Process, USEPA QA/G-4*, USEPA/600/R-96-055, 1996. Office of Research and Development, Washington, DC.

(8) ANSI/ASQC: *Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs (E4)*, 1994.