Office of Water Quality Technical Memorandum 2009.04

Subject: Reminders of How to Minimize Contamination of Volatile Organic Compound Samples

<table>
<thead>
<tr>
<th>Section</th>
<th>Summary of Key Steps to Minimize Contamination of VOC Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.a, 3.c</td>
<td>Purchase sample vials (i.e., VOA vials), foam sleeves, and Volatile Pesticide Blank Water (VPBW) from USGS One Stop</td>
</tr>
<tr>
<td>3.b</td>
<td>Store VOA vials, foam sleeves, and VPBW in a dedicated cabinet, in a VOC-free area; and store Trip Blanks (TBs) chilled, in the dark, and also in a VOC-free area</td>
</tr>
<tr>
<td>3.b</td>
<td>Load VOA vials, other sampling supplies, and pre-cleaned sampling equipment into field vehicles just prior to starting a field trip</td>
</tr>
<tr>
<td>3.d</td>
<td>Use a fresh, unopened bottle of VPBW to collect a Source-Solution Blank (SSB) and Field Blank (FB), and for the final rinse of the equipment cleaning procedure</td>
</tr>
<tr>
<td>3.f</td>
<td>Use ACS pesticide-grade methanol to clean sampling equipment; use about 2 liters for groundwater sampling equipment and wet all surfaces for surface-water equipment</td>
</tr>
<tr>
<td>3.g</td>
<td>Remove all methanol from sampling equipment, using the volume of VPBW specified in the National Field Manual (NFM)</td>
</tr>
<tr>
<td>3.h</td>
<td>Flush sampling equipment with groundwater or surface water prior to sample collection using, at minimum, the volume specified in the NFM</td>
</tr>
<tr>
<td>3.i</td>
<td>Use a ball-point pen to complete sample labels (do not use Sharpies)</td>
</tr>
<tr>
<td>3.j</td>
<td>Transport sampling supplies and equipment to field site in a manner that minimizes the risk of contamination</td>
</tr>
<tr>
<td>3.k</td>
<td>Quality assure the cleanliness of the sampling equipment and supplies via an equipment blank</td>
</tr>
</tbody>
</table>
1. Purpose and Scope

The main purpose of this memorandum is to remind field staff of some key steps to minimize contamination of water samples collected for analysis of Volatile Organic Compounds (VOCs). Requirements for the collection of Source-Solution Blanks (SSBs) and a warning about the possibility of well contamination by methanol also are discussed.

This memorandum gives emphasis to (1) purchase and storage of VOA vials, foam sleeves, and Volatile Pesticide Blank Water (VPBW); (2) use of VPBW; (3) required minimum volumes of methanol, VPBW, and native water rinsing; and (4) storage of equipment and sampling supplies during transit to sampling sites. Additional guidance in sampling for VOCs (e.g., the selection, care, and unique features of pumps) is discussed in the National Field Manual (NFM).

The need for this memorandum follows a recent review (2008) of field quality-control (QC) blanks which indicated that Field Blanks (FBs), for some VOCs, contain more frequent contamination, in comparison to groundwater samples. That is, FBs overstate the extent of contamination to groundwater samples. Estimating the extent of contamination in groundwater and surface-water VOC data sets requires the collection of representative FBs; “reminders” of how to minimize contamination can help to facilitate achieving this objective, and can reduce contamination in groundwater and surface-water samples.

The potential to contaminate water samples intended for VOC analyses is considered very large due to the ubiquitous sources of VOCs and, as such, extreme care must be taken during all aspects of sampling, processing, and shipment. Similar caution applies to the storage of supplies and sampling equipment at Water Science Centers (WSCs) and in field vehicles.

2. Background on Detection of VOCs in Field Quality-Control Blanks

A recent, comprehensive review of field QC data for VOCs, including Trip Blanks (TBs), field-collected SSBs, and FBs, by members of the Office of Water Quality’s Field QC Workgroup for Organics, indicates that some of these blanks contain VOC detections that are attributed to unknown source(s) of contamination at WSCs and/or during field activities. The National Water Quality Laboratory (NWQL) certifies the blank waters used for TBs, SSBs, and FBs. In general, VOCs are rarely identified (i.e., qualified) in the blank waters prior to shipment from the NWQL, and concentrations are reported as “less than the reporting level.” Furthermore, VOC detections in these field QC blanks cannot be attributed to laboratory contamination during sample analysis. Contamination may be occurring from a variety of sources during (1) shipment of TBs and VPBW from the NWQL to WSCs; (2) storage of these blank waters, VOA vials, methanol, other supplies, and sampling equipment at WSCs; (3) transportation to and from field sites; (4) equipment cleaning (e.g., from VOCs in methanol, tap water, and/or deionized water (DIW)); (5) sample collection (e.g., carryover from a prior sampling site); and (6) shipment of samples to the NWQL. Sources of contamination, while evident in field QC blanks, do not necessarily result in a VOC detection in samples of groundwater and surface water (see section 3.h on native water rinsing).

3. Description of Key Steps to Minimize Contamination of VOC Samples

a. Purchase of VOA Vials and Foam Sleeves – Studies completed as part of USGS National Programs are required to purchase VOA vials through USGS One Stop because these vials are
purchased by the NWQL and have the highest level of certification (i.e., low risk of VOC contamination), are of consistent size (necessary for laboratory autosamplers), and are bar coded. Note especially that the VOA vials purchased through USGS One Stop are used daily by the NWQL’s VOC Section to prepare lab blanks as part of VOC analyses. As such, the USGS One Stop supply of VOA vials is continually QCed using NWQL’s low-level VOC method, and if VOC contamination is noticed, immediate action can be taken by the NWQL to advise WSCs to terminate the use of vials from a specific lot. Foam sleeves used to pack VOA vials for shipment must also be purchased from USGS One Stop.

VOA vials and foam sleeves from USGS One Stop are highly recommended for other WSC projects because these supplies when purchased directly from commercial vendors may have a lower level of certification that allows larger amounts of VOC contaminants. Especially noteworthy is that there have been several incidences of contaminated VOA vials supplied by commercial vendors. VOA vials and foam sleeves are a very small fraction of the cost of collecting and analyzing a VOC sample, and there is little cost savings for a WSC to order these supplies directly from a commercial vendor. The quality assurance of VOA vials by the NWQL is viewed as an essential step to minimize the contamination of field QC blanks and water samples intended for VOC analyses.

b. **Storage of VOA Vials, Foam Sleeves, TBs, VPBW and Other Supplies at WSCs** – VOA vials, other supplies, and blank waters must be stored in a VOC-free area. Guidance on the storage of VOA vials and blank waters received from the NWQL is provided in Rapi-Note 01-018. This Rapi-Note specifically states that VOA vials and NWQL blank water are NOT to be stored (1) in a garage, or in a room next to a garage; (2) near office supplies and office equipment, such as photocopiers; and (3) near cleaning supplies. Storage in a WSC’s warehouse and laboratory also is not advised due to the presence of vehicle fumes, dust, solvents, cleaning chemicals, and other sources of VOCs. Furthermore, do not place VOA vials, other supplies, and blank waters in field vehicles and trailers until the start of a sampling trip.

Storage of field supplies intended for VOC sampling must be done with extreme care. A good storage area for VOA vials, foam sleeves, and VPBW is a dedicated storage cabinet located in a well-ventilated room that does not contain sources of VOCs. The storage cabinet should be located as far as possible from known sources of VOCs such as vehicles, generators, lubricants, paints, and liquids stored in a flammables cabinet. Before placing VOA vials and sleeves in the storage cabinet, these supplies should be re-packaged in a non-foam container or self-sealing plastic bag to further reduce the potential for contamination. Check to make sure the VOA vials have tight caps. Vials with loose caps must be discarded because they may have been contaminated prior to arrival at your WSC. TBs are required to be stored chilled, in the dark, and in a VOC-free area.

Methanol must be stored in a flammables cabinet; however, long-term storage is not advised. Previously opened bottles of methanol will act as a sink for VOCs from products containing VOCs that may be stored in the same cabinet. Separate flammables cabinets are recommended if methanol and gasoline must be stored in the same room.
c. **Purchase of VPBW** – VPBW must be purchased through [USGS One Stop](https://onestop.usgs.gov). This requirement is based on previous USGS experiences that commercially supplied "organic free water" contains VOCs that are easily detectable using NWQL's low-level analytical method. The VPBW that is supplied from the NWQL is purged with high-purity nitrogen for two hours to reduce any VOCs below detectable levels. This purging is done immediately before shipment to WSCs, and is an important quality-assurance step in collecting representative SSBs and FBs.

d. **Use of a Fresh, Unopened Bottle of VPBW at Sampling Site for SSB, FB, and Final Equipment Rinsing** – One use of the VPBW at a sampling site is to collect a SSB and FB. A fresh, unopened bottle of VPBW is required for a SSB and FB. Furthermore, the VPBW must be used by field crews within 14 days of it being purged with nitrogen at the NWQL. Holding VPBW longer than this time period (even in unopened bottles) increases the likelihood that the water will become contaminated with VOCs and thus cannot be used for a SSB or FB. Also, once a bottle of VPBW is opened and used at a sampling site, it cannot be used to collect a SSB or FB for VOCs at a subsequent sampling site. Previously opened bottles of VPBW may become contaminated with VOCs while stored in field vehicles and trailers, and during transit to another sampling site.

A fresh, unopened bottle(s) of VPBW must also be used in the final rinse of the equipment cleaning procedure (see section 3.g). Furthermore, a fresh, but partially used bottle of VPBW (left over from the collection of a FB at the same site and same day) may be used for part of the final rinse of the equipment cleaning procedure. Other requirements for VPBW, as noted above for SSB and FB, also apply to the use of VPBW in the final rinse of equipment cleaning procedure.

e. **National Field Manual Guidance on Methanol and VPBW** – The NFM provides detailed guidance on the minimum volume of methanol to be used in equipment cleaning, as well as the use of VPBW in the equipment cleaning procedure and in the processing of field blanks. It is imperative that the guidance be followed to assure that equipment is properly cleaned prior to use and that methanol is thoroughly removed from all equipment prior to collection of FBs, groundwater samples, and surface-water samples. Specific instructions in the NFM are given in the following chapters and sections:

*Use and volume of cleaning solutions in decontamination of equipment related to organic compound sample collection –*

  - Chapter A3, Section 3.2.2 – Organic-Compound Sampling Equipment
  - Chapter A3, Section 3.3.4.B – Plate Filter Assemblies and In-Line Filter Holder
  - Chapter A3, Section 3.3.5 – Sample Tubing
  - Chapter A3, Section 3.3.9 – Surface-Water Sampling Equipment
  - Chapter A3, Section 3.3.10 – Ground-Water Sampling Equipment
Use of VPBW in collection of organic field blanks –

Chapter A4, Section 4.3.1 – Blank Samples

Chapter A4, App.D2 – App.D3

f. Required Volume of Methanol in Equipment Cleaning Procedure for Groundwater and Surface-Water Sampling – The NFM requires the use of about 2 liters of American Chemical Society (ACS) pesticide-grade methanol in the cleaning procedure for groundwater sampling in which samples for VOCs, pesticides, and/or other organic contaminant groups will be collected (National Field Manual, chap A3 sec. 3.3.10.B). This volume is typically sufficient to assure wetting of all pump, tubing, and other surfaces (to dissolve organic contaminants) that will come in contact with groundwater during sample collection. Similarly, the rinsing of surface-water sampling equipment with methanol is satisfied after all surfaces of the VOC Hand Sampler and canister have been wetted (National Field Manual, chap A3 sec. 3.3.9). During the development of USGS's equipment cleaning protocol for sampling pesticides and VOCs, the use of methanol was “state of the science” and, therefore, considered an essential step in the cleaning procedure. The use of methanol was evaluated and reaffirmed in 2000.

There is some information that lesser amounts of methanol than described in the NFM have and continue to be used by some field staff. This may have compromised the comparability of subsequently collected samples by allowing carryover of VOCs to occur from the previous sampling site. Following the use of methanol as described in the NFM is explicitly required for organic samples collected in the NAWQA Program (National Field Manual, chap A3, table 3.1).

The NFM does not specify how previously opened bottles of methanol can be used or stored, or the shelf life of unopened and opened bottles of methanol. Members of the Field QC Workgroup for Organics support the development of specifications or guidelines for each of these issues; however, additional information must be collected and reviewed before recommendations can be made. In the interim, it would be prudent for WSCs to routinely monitor the results of their FBs for VOCs and, if detected, to determine if methanol is a source of contamination. If evident, contamination from methanol can be mitigated by (1) using fresh, unopened bottles of this solvent; and (2) making sure all methanol is removed from the sampling equipment. It would also be prudent to purchase methanol in 1-liter bottles to eliminate the need to store and transport partially used 4-liter bottles of methanol.

g. Required Volume of VPBW in Equipment Cleaning Procedure for Groundwater and Surface-Water Sampling – The minimum volume of VPBW required in the final rinse of the sampling line for groundwater sampling includes the volume of the sample line tubing (which depends on length and diameter of tubing) and an additional volume to remove methanol sorbed to the sample line tubing (see table 1). It is common for the required minimum volume of VPBW to be greater than 2 liters.

Appendix A provides example calculations of the required minimum volume of VPBW for the final rinse of the sampling line, and additional VPBW to fill the standpipe. This example can be followed for combinations of tubing lengths and diameters not shown in table 1.
Table 1. Minimum volume of VPBW for the final rinse of sample line tubing, in liters.1

<table>
<thead>
<tr>
<th>Total Tubing Length2 (feet)</th>
<th>Tubing Inside Diameter (inches)</th>
<th>1/8</th>
<th>1/4</th>
<th>3/8</th>
<th>1/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td>0.20</td>
<td>0.24</td>
<td>0.30</td>
<td>0.38</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>0.40</td>
<td>0.48</td>
<td>0.60</td>
<td>0.77</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>1.0</td>
<td>1.2</td>
<td>1.5</td>
<td>1.9</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>2.0</td>
<td>2.4</td>
<td>3.0</td>
<td>3.8</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>4.0</td>
<td>4.7</td>
<td>6.0</td>
<td>7.6</td>
</tr>
<tr>
<td>200</td>
<td></td>
<td>8.1</td>
<td>9.5</td>
<td>11.9</td>
<td>15.3</td>
</tr>
<tr>
<td>300</td>
<td></td>
<td>12.1</td>
<td>14.3</td>
<td>17.9</td>
<td>22.9</td>
</tr>
</tbody>
</table>

1The volume of VPBW required to fill the standpipe must be added to the volume indicated in the table.

2Total tubing length is length of the pump tubing and the length of the extension tubing (tubing from the manifold to the sampling chamber)

VPBW is also required in the final rinse of the equipment cleaning procedure for the VOC Hand Sampler. One 4-liter bottle of fresh, unopened VPBW is required. Allow the VOC Hand Sampler to air dry to the extent possible (to evaporate methanol), then complete the following two steps to rinse the sampler. First, fill a clean Teflon squeeze bottle with VPBW and using the squeeze bottle thoroughly rinse the copper inlet tubes and air/vent tube. Refill the squeeze bottle, if needed, to complete this initial step. However, all VPBW in the squeeze bottle should be used to rinse the sampler. Second, use all remaining VPBW left in the 4-liter bottle to do a copious rinse of the entire sampler by pouring the blank water directly from the VPBW bottle. All VPBW from the 4-liter bottle should be used for rinsing the sampler during these two steps.

Field crews cannot assume that methanol is free of VOCs. Commercially supplied methanol may contain or acquire large concentrations of some VOCs, for example, acetone, 2-butanone, and tetrahydrofuran. Furthermore, when methanol is used to clean equipment, it may absorb a wide variety of organic compounds. Removing all methanol from the sample line and VOC Hand Sampler is a critical step to eliminate carryover of VOCs and other organic compounds to subsequently collected FBs, groundwater samples, and surface-water samples. This is why it is especially important to use the required volume of VPBW in the final rinse step of the cleaning procedure. Not using at least the minimum volume of VPBW may cause sample contamination and adversely affect the quality of USGS data and, therefore, is not acceptable.

h. Importance of Native Water Rinsing Prior to Collecting Groundwater and Surface-Water Samples – It also is important to follow the NFM’s instructions with regards to well-purging requirements to, in part, achieve rinsing of all sample line tubing with groundwater before collecting groundwater samples. In addition to satisfying the purge requirements (and stabilization of field parameters), it is especially important to rinse the extension tubing (manifold to sample-chamber line). Rinsing with groundwater provides further assurance that contaminants, if any, remaining after equipment cleaning, are removed before a sample of
groundwater is collected. The NFM initially specified at least two tubing volumes of native water rinsing of the extension tubing before sample collection (National Field Manual, chap A4, section 4.2.1). However, a minimum of 10 tubing volumes of native water rinsing of the extension tubing is now (2009) required (National Field Manual, master errata for chap 4). About 11 minutes of rinsing is required to meet this 10-fold requirement, for a 10-foot length of 3/8-inch sample line, at a pumping rate of about 200 milliliters per minute (mL/min).

It is equally important to follow the NFM’s instructions with regards to native water rinsing of the VOC Hand Sampler (National Field Manual, chap A4, sec. 4.1.3.B). Specifically, the sampler should be submerged in the stream for several minutes, or dowsed three times with native water before the VOC vials are inserted into the sampler. Note that the VOA vials are NOT rinsed with native water prior to collection of a surface-water sample.

A special study completed by USGS staff and reported by Taglioli and others (2000) in Open-File Report 00-384 "Study design and analytical results used to evaluate carry-over contamination by VOCs in surface- and ground-water sampling procedures" demonstrated the effectiveness of native water rinsing in removing potential VOC carryover contamination prior to sample collection, when NFM procedures are followed precisely. The reader is referred to this report for additional details of the study.

Information on native water rinsing is found in the National Field Manual, chap A4, section 4.2.3A for well purging; section 4.2.4.A for supply wells; section 4.2.4.B for monitoring wells; and section 4.1.3.B for surface water.

i. Numbering of VOA Vials and Completion of Sample Labels – The three VOA vials filled for each blank, groundwater sample, and surface-water sample must be numbered in the sequence that the vials were filled (first vial filled is #1, second vial filled is #2, and third vial filled is #3). The NWQL will analyze the vials in inverse order of collection: vial #3, vial #2 (reruns and dilutions, if necessary), and vial #1 (additional reruns and dilutions, if necessary). The intent of this numbering and analysis scheme is to reduce the potential for contamination from the small diameter Teflon tube that channels the water sample into the VOA vials.

NWQL Technical Memorandum 1996.01 and Rapi-Note 01-018 specify that ballpoint pens must be used for labeling samples. Sharpie markers may contain xylenes and possibly other VOCs and, therefore, must not be used.

j. Storage of Sampling Equipment and Supplies during Transit to/from Sampling Sites – Supplies and equipment should be transported to and from sampling sites in a manner that minimizes the risk of contamination. Particular attention should be paid to the storage of the VPBW that is used for SSBs and FBs, VOA vials, and to all other surfaces that come into contact with the water resource being sampled. Field vehicles often carry contaminant sources, for example, gasoline, lubricants, insect sprays, personal care products, and waste methanol. When possible, secondary containment should be used to help isolate sampling supplies and equipment from potential sources of contamination. Examples of secondary containment include (1) separate compartments in/on vehicles; and (2) plastic tubs, boxes, and bags. Secondary containers should be cleaned regularly, inspected, and replaced, if necessary. As noted
previously, VOA vials and foam sleeves should be placed in self-sealing plastic bags and placed in non-foam storage containers.

**National Field Manual, chap A3**, section 3.2.2, instructs that, after cleaning (and for sampling sites where only organics will be sampled) the equipment must be stored by covering all orifices with aluminum foil or fluorocarbon polymer bags, and then placing the equipment into two clean, non-contaminating storage bags (such as the transparent covers used for the sample processing chamber). Furthermore, the **National Field Manual, chap A3**, section 3.3.10.B, states that cleaned submersible pumps and tubing be stored during transit by placing the pump into two clean, non-contaminating storage bags that are tied shut, and that the pump reel and tubing should be kept covered with doubled non-contaminating storage bags or sheeting.

At sampling sites where both organic and inorganic samples will be collected, the **National Field Manual, chap A3**, section 3.3.5 instructs that the cleaned equipment should NOT be wrapped or come in contact with aluminum foil, but rather placed dry, into two clean, non-contaminating storage bags and kept securely closed. The pump reel and tubing should be covered during transit as noted above.

**WRD Safety Memo 94.07** specifies how methanol (methyl alcohol) should be transported in field vehicles and includes precautions to prevent explosions due to excessive heat. The reader is referred to this memo for specific details.

**k. Quality Assurance Prior to the Start of Sampling** – In many WSCs the sampling of groundwater and surface water for VOCs is not a routine activity for field staff. Furthermore, sampling equipment may be used infrequently resulting in long-term storage, often in less than optimum locations. In such cases, the project chief and field staff should review the NFM for the most recent equipment requirements, cleaning procedure, and sampling protocols for VOCs. It is essential to assess the condition of equipment and its suitability for the planned sampling activity. In addition, completion of an acceptable equipment blank, that proves the cleanliness of the sampling equipment, is an essential QA practice. The NFM specifies that an equipment blank must be collected before a study’s field sampling is started and is recommended at least annually (**National Field Manual, chap A4**, sec. 4.3.1.A).

**4. Requirement of Source-Solution Blanks in the NAWQA Program**

SSBs are valuable for verifying the quality of blank water used for FBs and are required in the NAWQA Program for VOCs, wastewater indicator compounds, and dissolved organic carbon each time a FB is collected (T.L. Miller, Chief, NAWQA Program, Memorandum dated June 13, 2002). The requirements for VOCs and wastewater indicator compounds was described and updated in 2009 (D.N. Myers, Chief, NAWQA Program, Memorandum dated March 24, 2009).

**5. Warnings Concerning Well Contamination from Methanol**

Removing all methanol from the down-the-well pump and sample line tubing is important to prevent the inadvertent contamination of the water resource being sampled. Especially noteworthy is the failure of check valves in down-the-well pumps. These valves often do fail and thereby allow water in the pump and sample line tubing to backflow into the well water. Removal of all methanol from sampling
equipment by following the NFM procedures eliminates the potential for contamination of well water by 
residual methanol.

Selected References

Koterba, M.T., Wilde, F.D., and Lapham, W.W., 1995, Ground-water data-collection protocols and 
procedures for the National Water-Quality Assessment Program—Collection and documentation of 

Miller, T.L., NAWQA Memorandum dated 6-13-2002, “Change in NAWQA routine VOC QAQC 
requirements for ground water and surface water in Cycle II”, accessed January 8, 2009, at 
http://water.usgs.gov/nawqa-only/ftsуп/CycleII.VOC.QAQCGuidance.doc

Mueller, D.M., NAWQA Memorandum dated 10-16-07, Addendum to OFR 97-223, “Quality-control 
design for surface-water sampling (in) the NAWQA Program.”

Myers, D.N., NAWQA Memorandum dated 3-24-09, “Change in NAWQA field guidance; required 
analysis of source solution blanks for volatile organic compounds and wastewater indicator 
compounds.”

NAWQA internal web page, NAWQA Ground-water sampling protocols (revised Nov 2007), required 
use of methanol for organic analyses (pesticides or VOCs), accessed January 8, 2009, at 
http://water.usgs.gov/nawqa-only/ftsуп/GW/GWprotocols081108.doc

NAWQA internal web page, Ground water & trends assessment design, basic QC design, QC sample 
guidance, accessed January 27, 2009, at 

Taglioli, B.L., Delzer, G.C., and Zogorski, J.S., 2000, Study design and analytical results used to evaluate 
carry-over contamination by volatile organic compounds in surface- and ground-water sampling 
http://pubs.er.usgs.gov/usgspubs/ofr/ofr00384

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: 


U.S. Geological Survey National Water Quality Laboratory Technical Memorandum 1996.01, October 
23, 1995, “Guidelines for labeling 40-mL volatiles sample vials” by Brooke F. Connor, accessed 

note/01-018.html
This memorandum does not supersede any other OWQ Technical Memorandum.

Distribution: All WRD Employees
Appendix A. Example calculations for groundwater sampling of the minimum required volume of Volatile Pesticide grade Blank Water (VPBW) for (1) the final rinse of sample line tubing in the equipment cleaning procedure; (2) to collect a field blank; and (3) to complete both activities.

I. Determining the total minimum volumes of VPBW needed for the final rinse in the equipment cleaning procedure.

The total minimum volume must consider three items: (a) the volume required to fill the sample line tubing, including the pump-reel and extension tubing; (b) the volume required to fill the standpipe to operate the pump; and (c) the additional volume of VPBW required to rinse the sample line tubing (to remove methanol). Note especially that Table 1 only includes the required volumes for (a) and (c). The volumes for (b) should be added to the volumes listed in Table 1.

The following are applicable to calculating these three volumes, in gallons:

a. To estimate the volume of storage of the sample line tubing ($V_{tubing}$) –

$$V_{tubing} = V_{Lp} + V_{Le} = [(L_p \times C_p) + (L_e \times C_e)] \times C_1$$

where,

- $V_{Lp}$ is the volume of the pump-tubing segment being cleaned;
- $V_{Le}$ is the volume of the extension tubing being cleaned;
- $L_p$ is length of pump-tubing segment being cleaned, in feet;
- $L_e$ is length of extension tubing being cleaned, in feet;
- $C_p$ (or $C_e$) = volume of 1-foot length of tubing = 0.023 liter per foot for a 3/8-inch inside-diameter (ID) tubing or = 0.041 liter per foot for a 1/2-inch ID tubing; and
- $C_1$ is a conversion factor (0.264 gallon per liter).

b. To estimate the volume needed to fill a standpipe ($V_{sp}$) to a minimum level required to operate a pump –

$$V_{sp} = \pi \times (D_{sp}/2)^2 \times H_{sp} \times C_2$$

where,

- $V_{sp}$ is the volume of solution needed to fill standpipe, in gallons (or liters). This minimum volume corresponds to the level of solution in the standpipe, which, if maintained, allows pump to operate without introducing air through the pump intake;
- $\pi$ is pi (3.14);
- $D_{sp}$ is the diameter of the standpipe, in feet;
- $H_{sp}$ is the minimum height of water in the standpipe to operate the pump, in feet;
- $C_2$ is a conversion factor (7.48 gallon per cubic foot).

c. To estimate the volume needed for methanol rinsing ($V_{additional}$) – The NFM specifies that at least an additional 0.38 liter of VPBW must be pumped through the system for every 10 feet of methanol-wetted tubing.

d. The total minimum volume of VPBW required, $V_{total}$, is the sum of a, b, and c.
Example calculation for the total minimum volume of VPBW needed for final rinse in the equipment cleaning procedure:

Assumptions:

$L_p = 100$ feet of 3/8-inch tubing;
$L_e = 10$ feet of 3/8-inch tubing;
$C_p$ (or $C_e$) = 0.023 liter per foot for 3/8-inch inside-diameter (ID) tubing;
Standpipe diameter ($D_{sp}$) = 4 inches = 0.33 feet;
Height of water in standpipe ($H_{sp}$) to operate pump = 4 inches = 0.33 feet; and
$C_1 = 0.264$ gallon per liter.
$C_2 = 7.48$ gallon per cubic foot (28.3 liters per cubic foot)

<table>
<thead>
<tr>
<th>Volume Component</th>
<th>Criteria/Equation</th>
<th>Gallons</th>
<th>Liters</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Minimum tubing volume</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume of $L_p$ ($V_{L_p}$)</td>
<td>$0.023$ liter per foot for a 3/8-inch inside-diameter (ID) tubing</td>
<td>$100 \times 0.023 \times 0.264 = 0.6$</td>
<td>$100 \times 0.023 = 2.3$</td>
</tr>
<tr>
<td>Volume of $L_e$ ($V_{L_e}$)</td>
<td>$10 \times 0.023 \times 0.264 = 0.1$</td>
<td>$10 \times 0.023 = 0.23$</td>
<td></td>
</tr>
<tr>
<td>$V_{tubing} = V_{L_p} + V_{L_e}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Minimum volume in the standpipe ($V_{sp}$)</td>
<td>$\pi \times (D_{sp}/2)^2 \times H_{sp} \times C_2$</td>
<td>$0.029 \text{ ft}^3 \times 7.48 \text{ gal/ft}^3 = 0.2$</td>
<td>$0.029 \text{ ft}^3 \times 28.3 \text{ L/ft}^3 = 0.8$</td>
</tr>
<tr>
<td>c) Additional VPBW for methanol-wetted tubing ($V_{additional}$)</td>
<td>$0.38$ liter per 10 feet of sample line</td>
<td>$(0.38 \times 100/10 + 0.38 \times 10/10) \times 0.264 = 1.1$</td>
<td>$0.38 \times 100/10 + 0.38 \times 10/10 = 4.2$</td>
</tr>
<tr>
<td>d) The total minimum volume ($V_{total}$) of VPBW</td>
<td>$a + b + c = V_{tubing} + V_{sp} + V_{additional}$</td>
<td>$0.7 + 0.2 + 1.1 = 2.0$</td>
<td>$2.5 + 0.8 + 4.2 = 7.5$</td>
</tr>
</tbody>
</table>

2. Volume of VPBW needed to collect a field blank (or equipment blank).

If a field blank will be collected, then following the NFM guidance, rinse the pump exterior with VPBW and place the clean pump into the standpipe. In addition, the minimum volume of VPBW required to process a field blank is the sum of (1) the volume required in final rinse of the equipment cleaning procedure (see section 1 above) and (2) the small additional volume needed to fill the three 40-mL baked glass vials for volatile analyses. Fill the VOA vials from the last of the VPBW pumped through the equipment.

3. Summary of total minimum volume of VPBW needed for both equipment cleaning and collection of a subsequent field blank:

Assumptions:

$L_p = 100$ feet of 3/8-inch tubing;
$L_e = 10$ feet of 3/8-inch tubing;
$C_p$ (or $C_e$) = 0.023 liter per foot for 3/8-inch inside-diameter (ID) tubing;
Standpipe diameter ($D_{sp}$) = 4 inches = 0.33 feet; and
Height in standpipe ($H_{sp}$) to operate pump = 0.33 feet.
• Total minimum volume of VPBW needed for final rinse of the equipment cleaning procedure, with the above noted assumptions = **2.0 gallons = 7.5 liters.**

• Total minimum volume of VPBW needed to process a field blank = 2.0 + 0.03 = **2.0 gallons = 7.5 liters + 0.12 liters = 7.6 liters.**

• “Grand Total” minimum volume of VPBW needed to clean equipment and collect a subsequent field blank equals

\[
\begin{align*}
2.0 \text{ gallons} & + \ 2.0 \text{ gallons} = 4.0 \text{ gallons; or} \\
7.5 \text{ liters} & + \ 7.6 \text{ liters} = 15.1 \text{ liters.}
\end{align*}
\]

• The VPBW comes in a 4-liter bottle; therefore, a minimum of four bottles are needed to both clean the equipment and process a field blank at a sampling site (or an office equipment blank). Note these volumes do not include the volume of VPBW needed for rinsing the exterior of the pump and tubing during cleaning and prior to collection of a field blank. A fresh, unopened bottle of VPBW should be used at the sampling site for rinsing the exterior of the pump and tubing.