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ICR Treatment Studies Data Collection Spreadsheets User's Guide

by

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Foreword

The Information Collection Rule (ICR) for Public Water Systems (Subpart M of the National Primary Drinking Water Regulations, §141.141(e)) requires public water systems that meet certain applicability criteria to conduct disinfection byproduct (DBP) precursor removal studies, referred to as treatment studies. These treatment studies are intended to provide cost and performance data on granular activated carbon (GAC) and membrane processes for meeting proposed DBP regulations.

A rule by reference document, the *ICR Manual For Bench- and Pilot-Scale Treatment Studies* (EPA 814-B-96-003, April 1996), states that the *Final Treatment Study Report* shall consist of data collection software containing the actual treatment study data and a hard-copy summary report containing details of the study not included in the software.

The purpose of the *ICR Treatment Studies Data Collection Spreadsheets* and the accompanying *User's Guide* is to provide a mechanism for reporting the results from the ICR Treatment Studies to EPA in a uniform, electronic format. The user's guide is intended to:

- Describe the use of the *Data Collection Spreadsheets* in reporting treatment study results.
- Provide example spreadsheets containing data to demonstrate the use of the spreadsheets.
- List the nomenclature and equations used in the *Data Collection Spreadsheets*.
- Provide detailed guidance on the preparation of the hard-copy *Treatment Study Summary Report* that will complement the data contained in the *Data Collection Spreadsheets* in the *Final Treatment Study Report*.

The spreadsheets and user's guide are being provided to all public water systems potentially subject to the ICR Treatment Study requirement, as well as all ICR approved laboratories that may provide analytical support for the treatment studies. Additionally, a limited number of copies will be provided through the Safe Drinking Water Hotline at no charge. These additional copies are intended for consultants and laboratories that are involved in conducting treatment studies or providing analytical support for the studies. To order a copy of the *ICR Treatment Studies Data Collection Spreadsheets* and *User's Guide* through the Safe Drinking Water Hotline call 1-800-426-4791.

Copies of the *ICR Treatment Studies Data Collection Spreadsheets* and *User's Guide* are also available for a fee from the National Technical Information Services (NTIS), U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161. The toll free number for NTIS is 1-800-553-6847.

Notice

This document has been subjected to the Agency's peer and administrative review process, and it has been approved for publication as an EPA document. This product has been reviewed at various stages of development by independent, technical experts both within and outside of the Agency. Reviewers were selected on the basis of their knowledge of the ICR treatment study requirements as well as experience in conducting and reporting the results from pilot- or bench-scale studies; however, there was no requirement that the reviewers be familiar with spreadsheet applications since this product is intended for use by a general audience. Additionally, individuals that are likely to use the final product (i.e., water utility personnel, consultants and laboratory personnel) were targeted as reviewers.

The selected reviewers were mailed a draft copy of the document and spreadsheets along with a review form and letter providing instruction for the review. Reviewers were asked to provide written comments on the appropriateness of spreadsheets for reporting the results from the ICR Treatment Studies, the usability of the spreadsheets, the clarity of the instructions in the *User's Guide*, the proposed format for the *Treatment Study Summary Report*, and any other issues identified by the reviewer. All of the written comments received from the reviewers are maintained in the peer review record for this product. The major comments and the manner in which they were addressed are summarized here.

- In general, the reviewers commented that the *Data Collection Spreadsheets* are an acceptable mechanism for submitting the results from the treatment studies, and that the spreadsheets are easy to use when following the documentation and example spreadsheets in the *User's Guide*. Some reviewers did comment that the large size of these spreadsheets may make them cumbersome to use. Unfortunately, the large size is necessary to report all of the detailed data that will be generated during the treatment studies. In order to make these large spreadsheets easier to navigate, an Excel workbook format was utilized, which uses different worksheets to capture different data sets.
- Reviewers commented that the instructions in the user's guide are clear and easy to follow, and many indicated that the hard-copy spreadsheet fields and the appendices containing the nomenclature and equations were especially helpful.
- In general, the reviewers commented that the hard-copy *Treatment Study Summary Report* is a good mechanism to capture the details of the study that are not included in the *Data Collection Spreadsheets*. However, some reviewers felt that more detailed guidance on the preparation of this report was required. To address this concern, the proposed outline for the *Treatment Study Summary Report* was redesigned to focus on the essential information to be included in this report, and extraneous reporting requirements were deleted. Guidance on the preparation of this summary report was revised to include detailed requirements and numerous examples of the elements to be included in the report.
- Some reviewers commented that the QA/QC reporting requirements in the review draft of the guide were not well defined. To address this concern a subsection was added to the document specifying the information that must be included in the QA/QC Summary section of the *Treatment Study Summary Report*.

- One reviewer suggested that the spreadsheets be formatted to print each field in a field-set. To address this comment the spreadsheets were formatted with predefined views and reports that can easily be printed using the View Manager and Report Manager tools in Excel.
- A few comments and suggestions were received regarding the technical aspects of conducting treatment studies. The requirements and guidance for conducting ICR Treatment Studies are included in the *ICR Manual For Bench- and Pilot-Scale Treatment Studies* (EPA 814-B-96-003, April 1996) which is a rule by reference document. The purpose of the *Data Collection Spreadsheets* and *User's Guide* is to provide a streamlined mechanism for reporting the results from the treatment studies. Modifications to the technical and regulatory requirements of the ICR is outside the scope of this document.

Disclaimer: Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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1.0 Introduction

The purpose of this guide is to assist public water systems (PWSs) in reporting the results from the ICR treatment studies to EPA. A PWS must submit one *Final Treatment Study Report* for each treatment study conducted by a treatment plant operated by the PWS. ***The Final Treatment Study Report* is due in its entirety no later than July 14, 1999.** As stated in Part 1 of the *ICR Manual For Bench- and Pilot-Scale Treatment Studies* (EPA 814-B-96-003, April 1996), the *Final Treatment Study Report* shall consist of data collection software containing the actual treatment study data and a hard-copy summary report containing details of the study not included in the software. The data collection software will be referred to as the *ICR Treatment Study Data Collection Spreadsheets* (or just *Data Collection Spreadsheets*) and the hard-copy summary report will be referred to as the *Treatment Study Summary Report*.

This guide describes the *Data Collection Spreadsheets* that must be used to report the results from the treatment study. Specific spreadsheets are provided for both GAC and membrane technologies using either pilot- or bench-scale testing approaches. This document also contains guidance on the preparation of the hard-copy *Treatment Study Summary Report* which will accompany the *Data Collection Spreadsheets* in the *Final Treatment Study Report*. This guide is organized as follows:

- **Section 2.0**, Selecting And Loading The Appropriate *Data Collection Spreadsheets*, explains how to select the correct compressed spreadsheet file for a specific type of treatment study, and how to “extract” the working file(s) from the compressed file.
- **Section 3.0**, Using The *Data Collection Spreadsheets*, describes the format and organization of the *Data Collection Spreadsheets* and provides a general explanation of the use of these spreadsheets.
- **Section 4.0**, Spreadsheet For GAC RSSCT Bench-Scale Studies, describes the spreadsheet used to report the results from RSSCT, bench-scale GAC studies.
- **Appendix 4a**, GAC RSSCT Equations And Nomenclature, lists the nomenclature and equations used in the GAC RSSCT spreadsheet.
- **Section 5.0**, Spreadsheet For GAC Pilot-Scale Studies, describes the spreadsheet used to report the results from pilot-scale GAC studies.
- **Appendix 5a**, GAC Pilot-Scale Equations And Nomenclature, lists the nomenclature and equations used in the GAC pilot-scale spreadsheet.
- **Section 6.0**, Spreadsheets For Membrane RBSMT Bench-Scale Studies, describes the spreadsheets used to report the results from RBSMT, bench-scale membrane studies.
- **Appendix 6a**, Membrane RBSMT Equations And Nomenclature, lists the nomenclature and equations used in the membrane RBSMT spreadsheets.
- **Section 7.0**, Spreadsheets For Membrane SEBST Bench-Scale Studies, describes the spreadsheets used to report the results from SEBST, bench-scale membrane studies.
- **Appendix 7a**, Membrane SEBST Equations And Nomenclature, lists the nomenclature and equations used in the membrane SEBST spreadsheets.
- **Section 8.0**, Spreadsheet For Membrane LT-SEBST Bench-Scale Studies, describes the spreadsheet used to report results from long-term SEBST, bench-scale membrane studies.

- **Appendix 8a**, Membrane LT-SEBST Equations And Nomenclature, lists the nomenclature and equations used in the membrane LT-SEBST spreadsheet.

- **Section 9.0**, Spreadsheet For Membrane Pilot-Scale Studies, describes the spreadsheet used to report the results from pilot-scale membrane studies.
- **Appendix 9a**, Membrane Pilot-Scale Equations And Nomenclature, lists the nomenclature and equations used in the membrane pilot-scale spreadsheet.
- **Section 10.0**, Format For Hard-Copy *Treatment Study Summary Report*, provides guidance on the preparation of a summary report that captures details of the study not included in the *Data Collection Spreadsheets*.
- **Section 11.0**, Submitting The *Final Treatment Study Report*, lists the address and format for submitting the *Final Treatment Study Report*.

The following sections provide general instruction on the use of these spreadsheets, as well as guidance on the preparation of the hard-copy *Treatment Study Summary Report*: Section 2.0, Selecting And Loading The Appropriate *Data Collection Spreadsheets*; Section 3.0, Using The *Data Collection Spreadsheets*; Section 10.0, Format For Hard-Copy *Treatment Study Summary Report*; and Section 11.0, Submitting The *Final Treatment Study Report*. **It is recommended that everyone read these four sections.**

Sections 4.0 through 9.0 are self-contained and independent of one another, and **only those sections relevant to the study being conducted need to be read**. For example, if only RSSCT studies are being conducted, the user only needs to read Section 4.0, Spreadsheet For GAC RSSCT Bench-Scale Studies, and Appendix 4a, GAC RSSCT Equations And Nomenclature.

The detailed requirements and guidance for conducting the treatment studies are not included in this guide, but rather in the *ICR Manual for Bench- and Pilot-Scale Treatment Studies*. It is assumed that the user of this guide is familiar with the details of the treatment study for the particular technology and scale being investigated.

Questions regarding use of the *Data Collection Spreadsheets* should be directed to the Safe Drinking Water Hotline at 1-800-426-4791 or the ICR Treatment Studies Coordinator at 513-569-7131.

2.0 Selecting And Loading The Appropriate *Data Collection Spreadsheets*

The spreadsheets were developed for use with **EXCEL Release 5.0** for **WINDOWS**. Newer releases of Excel (i.e., Release 7.0) will be able to read these spreadsheet files; however, older versions or different spreadsheet applications may not be able to read these files. Excel is the preferred software application for use with the *Data Collection Spreadsheets* since other software applications perform certain calculations differently than Excel. However, if you do not have access to Excel 5.0 or later a version of Excel, you may contact the ICR Treatment Studies Coordinator at 513-569-7131 to request the *Data Collection Spreadsheets* in a different software format.

All of the Excel spreadsheet files are contained on three enclosed diskettes as six self-extracting, compressed files. (The fourth diskette contains PKZIP compression software which will be discussed later in this section.) Each compressed file is specific to a particular type of treatment study, and Table 2-1 lists the compressed files along with the corresponding working files (note that the compressed files *rbsmt.exe* and *sebst.exe* contain multiple working files). Use this table to select the self-extracting, compressed file that corresponds to the treatment study that you are conducting.

Before the spreadsheets can be opened in Excel, the working files must be extracted from the compressed files. The file extraction procedure is as follows:

1. Insert the diskette containing the appropriate compressed file into the 3.5 inch floppy drive of your computer, and use the File Manager (Windows 3.1x) or Windows Explorer (Windows 95) to view the files on the diskette.
2. Double click on the compressed file name corresponding to the study being conducted (e.g., if RSSCT studies are being conducted, double click on *gacrssct.exe*). A "PKSFX" window will open.
3. Under "Extract To," select the drive and directory where you want the working files to be located after they are extracted (e.g., *C:\icr\gacstudy*). **CAUTION: do not extract the working files to the floppy diskette.**
4. Click on the "Extract" button to begin extracting the working files.
5. If the directory specified under Step 3 does not exist, then a window will open giving you the option to create the directory. Click the "Yes" button if you want to create the directory.
6. Once the extraction is complete, the files can be viewed in the directory selected in Step 3.

As shown in Table 2-1, Disk 4 of the *ICR Treatment Study Data Collection Spreadsheets* contains a licensed copy of PKZIP, which is a software application used to compress computer files. It may be necessary to use PKZIP to compress the *Data Collection Spreadsheets* so that the files can be returned to EPA using standard 3.5 inch, 1.44 MB high density diskettes.

Note: The PKZIP software included with the *ICR Treatment Study Data Collection Spreadsheets* is only licensed for use during submission of ICR treatment study results to EPA. Any other use of this licensed copy of PKZIP is prohibited.

Before the PKZIP compression software can be used, it must be installed to the hard drive (or network) of your computer. The following procedure is used to install PKZIP:

1. Insert Disk 4 of the *Data Collection Spreadsheets* into the 3.5 inch floppy drive of your computer, and use the File Manager (Windows 3.1x) or Windows Explorer (Windows 95) to view the files on the diskette.
2. If you are using Windows 3.1x, double click on the file *setup16.exe*. If you are using Windows 95 or Windows NT, double click on the file *setup.exe*. A "PKSFX" window will open.
3. The default directory for the installation of PKZIP is *C:\PKWARE\PKZIPW*. If this directory is acceptable, proceed to Step 4; if not, enter the new path and directory for the installation of PKZIP.
4. Click the "Extract" button to begin extracting the working files.
5. If the directory specified under Step 3 (e.g., *C:\PKWARE\PKZIPW*) does not exist, then a window will open giving you the option to create the directory. Click the "Yes" button if you want to create the directory.
6. Once the extraction is complete, a window will open which says "Authentic files verified! # PKW655." Click the "OK" button to close this window. Next, a window will open which says "Extraction complete." Click the "OK" button to close this window.
7. Instruction on the use of PKZIP compression software is included in Section 3.5.

Compressed File	Disk #	Working File(s)	Description of Working File(s)
gacpilot.exe	Disk 1	*gacpilot.xls*	Pilot-scale GAC spreadsheet
gacrssct.exe	Disk 1	*gacrssct.xls*	RSSCT GAC spreadsheet
rbsmt.exe	Disk 1	*rbsmt-1.xls* *rbsmt-2.xls*	RBSMT spreadsheet, 1st membrane RBSMT spreadsheet, 2nd membrane
sebst.exe	Disk 2	*sebst-1.xls* *sebst-2.xls*	SEBST spreadsheet, 1st membrane SEBST spreadsheet, 2nd membrane
ltsebst.exe	Disk 2	*ltsebst.xls*	Long-term SEBST spreadsheet
mempilot.exe	Disk 3	*mempilot.xls*	Pilot-scale membrane spreadsheet
setup16.exe	Disk 4	*pkzipw.exe*	PKZIP compression software for Windows 3.1x
setup.exe	Disk 4	*pkzipw.exe*	PKZIP compression software for Windows 95 & Windows NT

Table 2-1 Summary Of Compressed And Working *Data Collection Spreadsheet* Files

3.0 Using The *Data Collection Spreadsheets*

3.1 Opening The Spreadsheets

The *ICR Treatment Study Data Collection Spreadsheets* are opened in the same manner as typical spreadsheet applications:

1. Open Excel 5.0 by double clicking on the program icon.
2. Once the application is running, select File then Open, and then specify the appropriate Drive, Directory and File Name for the Excel working file.
3. Click the OK button to open the specified working file.

3.2 General Organization Of The Spreadsheets

The *Data Collection Spreadsheets* are similar to other spreadsheet applications; however, they are organized in a specific manner for the purpose of reporting results from the treatment studies. These spreadsheets are organized into **fields-sets** which consist of several **fields**, and **fields** are made up of one or more **blocks** of **cells**. These terms are defined as follows:

- **Cells** are the individual units that make up a spreadsheet, and groups of related cells are organized into **blocks** and **fields**. Each cell is defined by a unique address that consists of a single or double letter identifying the cell column and a number identifying the cell row (e.g., B2, S45, BD104). In these spreadsheets, cells are used to enter datum such as a TOC concentration, or text such the name of a pretreatment process.
- **Blocks** are groups of **cells** (e.g., B5:F24) containing related data elements, and one to several blocks make up a **field**. In these spreadsheets, blocks are used to enter groups of similar data such as the input design parameters for a GAC pilot run or one set of weekly water quality results from a single element membrane study.
- **Fields** consist of one or more **blocks** that contain related data elements. Similar to blocks, fields are used to enter groups of related data, but in some cases multiple **blocks** of data make up a single **field**.
- **Field-sets** consist of several **fields**. A single field-set is used to report the complete set of results from one study. For example, one field-set in the *gacrssct.xls* file is used to report all of the results from one quarterly RSSCT study. In the *Data Collection Spreadsheets*, individual field-sets are contained in separate worksheets.

  Note: Many of the fields in these spreadsheets are similar to the data tables included in Parts 2 and 3 of the *ICR Manual for Bench- and Pilot-Scale Treatment Studies*.

3.3 Spreadsheet Equations And Cell Protection

The *Data Collection Spreadsheets* are designed to perform many automatic calculations; however, the calculations will only yield correct results if the data are entered in the specified units. **Thus, it is critical that data entered in the spreadsheets be consistent with the listed units.** Cells that contain equations are indicated by shading, and data should never be entered directly into these cells unless there is a need to overwrite the equation and enter a value directly into the spreadsheet. In order to prevent the accidental deletion of spreadsheet equations, the spreadsheet has been "protected" all cells containing equations have been "locked." If it is necessary to overwrite or modify an existing equation, the following procedure can be used to unprotect the sheet and unlock specific cells:

1. From the Excel menu bar select Tools then Protection then Unprotect Sheet. This will allow all cells in the spreadsheet file to be modified.
2. In order to unlock specific cells, first "unprotect" the sheet as described in Step 1. Next select the cells which are to be unlocked, then from the menu bar select Format then Cells then the "Protection" tab, then click on the box next to Locked and click the "OK" button. If there is an "x" next to Locked then the selected cells will remain locked after the sheet is protected, while an empty box next to Locked indicates that the cells will be unlocked after the sheet is protected.
3. In order to protect the sheet after making modifications, select Tools then Protection then Protect Sheet. A "Protect Sheet" window will open with an option to enter a Password. **Do not enter a password**. Make sure that an "x" appears in each of the three boxes in this window and click the "OK" button. This will protect the spreadsheet and prevent locked cells from being modified.

   Tip: Worksheets will need to be Unprotected in order to print a View or a Report. See Section 3.6, Printing The Spreadsheets, for a further explanation of printing Views and Reports.

Every *Data Collection Spreadsheet* file includes one example field-set which contains example data. The purpose of these example field-sets is to clarify the use of the spreadsheets and to verify that the spreadsheet equations are functioning properly. Equations can be indirectly verified by comparing values on the hard-copy example fields, included as exhibits in Sections 4.0 through 9.0, with the calculated values in the example fields in the spreadsheet files. Direct verification of spreadsheet equations is performed by manually calculating a value and comparing it with the value calculated by the spreadsheet. **All equations and nomenclature used in these spreadsheets are listed in the appendix to each section.**

The spreadsheet equations have been extensively tested, and it is unlikely that any of the equations will produce erroneous results unless the file has been corrupted. **If an equation appears to be producing erroneous results, the user should check that all cells referenced by the spreadsheet equation contain correct values reported in the specified units.**

In most cases, it will not be necessary to insert cells, columns, or rows into the spreadsheets. If it is necessary to insert cells into the spreadsheet, the situation should be evaluated to determine wether it is more appropriate to insert individual cells/groups of cells or entire rows/columns. If cells, rows or columns are inserted into the spreadsheet, it is important to verify that this action does not affect the automatic spreadsheet calculations.

3.4 Entering Data In The Spreadsheets

As with any other spreadsheet application, data are entered into the appropriate cells by clicking on that cell and typing in the appropriate value. Unlike cells containing equations, data entry cells are not "locked" and are not shaded. Data entry cells are used to report numeric values such as the concentration of a specific water quality parameter, or text such as a process description.

There may be cases in which a numeric value will not be entered into a cell used to report the results from a water quality analysis. For example, the concentration may be below the minimum reporting level (MRL) or the analysis may have failed QA/QC criteria. The following is a list of symbols that should be used to indicate that a value could not be reported for a specific water quality analysis:

BMRL = Below the minimum reporting level
NA = Not analyzed
NR = Not reported due to a QA/QC failure

BMRL is used to indicate that the concentration of a specific analyte was below the minimum reporting level for that analysis. The minimum reporting levels used in the ICR are specified in the *DBP/ICR Analytical Methods Manual* (EPA 814-B-96-002, April 1996). It is acceptable to use MRLs lower than those specified in the DBP Manual if the following criteria are met: the MRL must be equal to or greater than twice the minimum detection level, and the lab must meet the QC acceptance criteria for the MRL concentration listed in the *DBP/ICR Analytical Methods Manual* at the lower MRL concentration (e.g., if a laboratory reports an MRL of 0.2 mg/L for TOC, then the blank must be $<$ 0.1 mg/L, the low level calibration verification standard concentration must be 0.2 mg/L, the precision at 0.2 mg/L must be $\leq$ 20% RPD, etc.). The MRL for each water quality parameter analyzed during the treatment study must be reported in the *Treatment Study Summary Report* as described in Section 10.5.

NA is used to indicate that a sample was not analyzed. Possible reasons that NA may be reported include: optional water quality parameters that were not analyzed, samples that have exceeded the specified holding time, broken sample bottles, improper storage conditions, etc. **NR** indicates that a sample was analyzed but not reported due to a QA/QC failure, such as failure to verify instrument calibration at the required frequency, failure to meet acceptance criteria for a calibration verification standard, failure to run a duplicate analysis when required, etc.

Note: Excel treats text entries such as **BMRL**, **NA** and **NR** as *no data entry*, and ignores these entries when performing calculations. Example: Assuming the following data are entered into an Excel spreadsheet, **5**, **7**, **9**, **BMRL**, and **NA**, Excel will calculate the **sum** of these five entries as **21** and the **average** as **7**. Also, the spreadsheets are set up to calculated the sum of average values, not the average of two or more sums (e.g., for a duplicate THM4 analysis, the average THM4 concentration is calculated by computing the average for each individual THM and summing these four average concentrations).

Note: The analytical results from the treatment studies will not undergo the automated QA/QC review process used to validate the results from the 18 months of ICR monitoring. Rather, the QA/QC Summary in the hard-copy *Treatment Study Summary Report* will be evaluated to determine whether or not the QA/QC procedures specified in the *ICR/DBP Analytical Methods Manual* were followed, and to assess the quality of the data. The evaluation of this QA/QC information will be used to determine whether or not the results from the treatment study are used in the data analysis. **It is the responsibility of the PWS and laboratory to screen individual analytical results to ensure that only data meeting the QA/QC criteria are entered into the *Data Collection Spreadsheets*.** The laboratory and PWS must also maintain a record of the QA/QC followed during the treatment study, and in the event of an audit, this documentation must be made available to EPA.

3.5 Saving And Compressing The Spreadsheets

After entering data into a spreadsheet, the file can be saved using the current file name or a new file name by invoking the Save or Save As command, respectively. When all of the data have been entered into the *Data Collection Spreadsheets*, the file(s) should be copied onto a new diskette(s) which will be returned to EPA as part of the *Final Treatment Study Report*.

After data has been entered into the *Data Collection Spreadsheets*, the files may be too large to be saved to standard 1.44 MB high density diskettes. In this case it will be necessary to reduce the file size by: (1) deleting worksheets in the *ICR Treatment Study Data Collection Spreadsheet* which do not contain treatment study data (e.g., example field-sets or empty field-sets); and/or (2) compressing the file using the PKZIP software included on Disk 4 of the *ICR Treatment Study Data Collection Spreadsheets.*

The following procedure is used to compress files using the PKZIP software:

1. Install the PKZIP software as described in Section 2.0.
2. Open the PKZIP software by double clicking on the program icon.
3. From the PKZIP menu bar, click File and then New. A "Save As" window will open.
4. Under File Name, specify the name that you wish to assign to the compressed file. In order to help EPA track the *Data Collection Spreadsheets*, name the file using the following format: **ICR**, followed by the **three or four digit plant ICR#**, followed by the **.zip** extension (e.g., *ICR1234.zip*).
5. Under Directories and Drives, select the location where you want the compressed file to be created.
6. An "Add Files" window will open in which you must specify the file(s) that are to be compressed. Select the Drive and Directory containing the file(s) to be compressed.
7. Highlight the name of the file(s) that you wish to store in the compressed file specified in Step 4. Click the "Add Files" button.
8. The file(s) will appear under "Files and Directories to Zip." Once all of the file(s) have been selected, click the "OK" button.
9. An "Add Status" window will open while the files are being compresses. When the compression has been completed, click the "Done" button.
10. A window will open containing information about the file(s) contained in the compressed file. Close this window.
11. Close PKZIP for Windows.
12. Copy the compressed file to a 3.5 inch diskette for submission as part of the *Final Treatment Study Report*.
13. Details regarding the logistics of data submission are discussed in Section 11.0.

3.6 Printing The Spreadsheets

The fields in the *Data Collection Spreadsheets* can be printed using one of three different procedures: printing selections, printing views, or printing reports. Of these three approaches, printing views is preferred since this procedure is quicker than printing selections and produces a superior format compared to printing reports. Instructions for each of these printing procedures will be discussed in this section.

Printing Selections is the most involved printing procedure, but may be the only option available if certain Add-Ins are not available in the Excel package being used. (Excel Add-Ins are discussed on page 3-7.) This procedure requires the user to select a field, setup the page and print the selection. The following steps are use to print a selection:

1. Select the block of cells to be printed (e.g., this is typically one field).
2. From the File pull-down menu select Print. A "Print" window will open.
3. Under the heading "Print What" select Selection.
4. Click on the "Page Setup" button and go to the "Page" tab.
5. Under the heading "Orientation" select the orientation of the sheet (i.e., Portrait or Landscape).
6. Under the heading "Scaling" select "Fit to __ pages wide by __ tall" and enter the appropriate number of pages in each blank. Once the orientation and scaling have been specified, click the "OK" button to accept the page setup and to close the "Page Setup" window.

   Tip: The hard-copy printouts of the fields included in this document can be used to select an appropriate page setup for a field (i.e., Portrait vs. Landscape, and an estimate of the number of pages required to print each field).

7. After closing the "Page Setup" window, you will return to the "Print" window. Click the "OK" button to print the selection according to the page setup specified in Steps 5 and 6.
8. Repeat this procedure for all fields to be printed.

Printing Views is similar to printing selections except that printing views takes advantage of predefined views saved in the *Data Collection Spreadsheets*. In order to print views, the View Manager must be available in the Excel package being used (see the discussion on Excel Add-Ins on page 3-7). Also, to enable the View Manger, the worksheets must be Unprotected. The following procedure is used to print a predefined view:

1. Assuming that the worksheet is protected, the first step is to Unprotect the worksheet. From the Tools pull-down menu select Protection and Unprotect Sheet to enable the View Manager.
2. From the View pull-down menu select View Manager, and a "View Manager" window will open.
3. Under Views, select the view that you wish to print. The name of each view corresponds to the field designation in the worksheet.
4. Click the "Show" button to go to the selected view.
5. From the File pull-down menu select Print. A "Print" window will open.
6. Click the "Page Setup" button and go to the "Page" tab.
7. Under the heading "Orientation" select the orientation of the sheet (i.e., Portrait or Landscape).
8. Under the heading "Scaling" select "Fit to __ pages wide by __ tall" and enter the appropriate number of pages in each blank. Once the orientation and scaling have been

specified, click the "OK" button to accept the page setup and to close the "Page Setup" window.

Tip: The hard-copy printouts of the fields included in this document can be used to select an appropriate page setup for a field (i.e., Portrait vs. Landscape, and an estimate of the number of pages required to print each field).

9. After closing the "Page Setup" window, you will return to the "Print" window. Click the "OK" button to print the selection according to the page setup specified in Steps 7 and 8.
10. Repeat this procedure for all fields to be printed.

    Tip: Additional views can be defined by the user. To create a view, select the block of cells that are to be included in the view. Next, click the "Set Print Area" button, located on the Excel tool bar. From the View pull-down menu select View Manager, and a "View Manager" window will open. Click the "Add" button and an "Add View" window will open. Under the heading "View Includes," make sure that the box next to Print Settings is checked. Enter a Name for the view and click the "OK" button to save the view.

Printing Reports allows a user to print all of the fields in a field-set in one report. This is the most efficient way to print an entire field-set; however, it will produce the poorest format of the three printing procedures since the Report Manager allows only one Page Setup to be used for the entire report.

In order to print a report, the Report Manager and the View Manager must be available in the Excel package being used (see the discussion on Excel Add-Ins on page 3-7). Also, to enable the Report Manger and the View Manger, the worksheets must be Unprotected. The following procedure is used to print a report:

1. Assuming that the worksheet is protected, the first step is to Unprotect the worksheet. From the Tools pull-down menu select Protection and Unprotect Sheet to enable the Report and View Managers.

   Tip: The correct Page Setup for each report has been saved in each worksheet, and if the *orientation* and *scaling* have not been changed from the default values, then Steps 2 through 5 can be skipped.

2. From the File pull-down menu select Page Setup, and a "Page Setup" window will open.
3. Select the "Page" tab in the "Page Setup" window.
4. Under the heading "Orientation" select Landscape orientation.
5. Under the heading "Scaling" select "Fit to __ pages wide by __ tall" and enter the number of pages in each blank that are required to print the LARGEST field in each field-set. Once the orientation and scaling have been specified, click the "OK" button to accept the page setup and to close the "Page Setup" window.
6. From the File pull-down menu select Print Report, and a "Print Report" window will open.
7. Under the heading "Reports," select the report that you wish to print. The name of each report corresponds to a worksheet title (i.e., a field-set).

8. Click on the Print button to print the selected report.

   Tip: Additional reports can be defined by the user. To create a report, select the File pull-down menu and select Print Report. A "Print Report" window will open. Click the "Add" button and an "Add Report" window will open. Enter a Report Name and specify the Sheet and each View that you want to add to the report. For each View, click the "Add" button, and the View will appear under the heading "Sections in this Report." Once all of the Views have been added to the report, click the "OK" button to save the report. Close the "Print Report" window.

Excel Add-Ins are tools that may not be available in some Excel setups. Two Add-Ins are relevant to printing fields from the *Data Collection Spreadsheets*, the View Manager and the Report Manager. To add these tools to Excel, select the Tools pull-down menu and select Add-Ins. Make sure that an "x" appears in the boxes next to View Manager and Report Manager, and then click the "OK" button. This will make the View Manager and Report Manager available in Excel.

4.0 Spreadsheet For GAC RSSCT Bench-Scale Studies

The RSSCT spreadsheet (*gacrssct.xls*) is designed to contain all of the data from four quarterly RSSCT studies, with each study consisting of both a 10- and a 20-minute EBCT run. This spreadsheet consists of five (5) field-sets with nine (9) fields in each field-set. Each field-set is located on a separate worksheet, and Table 4-1 summarizes the designation, sheet title and cell range for each field-set.

Field-Set Title (Designation)	Sheet Title	Field-Set Cell Range
Example RSSCT Data (E-)	Sheet0. Example Data	A1:CZ57
1st Quarter RSSCT Results (1-)	Sheet1. 1st Quarter	A1:CZ57
2nd Quarter RSSCT Results (2-)	Sheet2. 2nd Quarter	A1:CZ57
3rd Quarter RSSCT Results (3-)	Sheet3. 3rd Quarter	A1:CZ57
4th Quarter RSSCT Results (4-)	Sheet4. 4th Quarter	A1:CZ57

Table 4-1 Summary Of RSSCT Field-Sets And Corresponding Sheet Titles

The Example Field-Set (Fields E-1 to E-9) demonstrates the use of the RSSCT spreadsheet. Example data are presented in each field to clarify the use of these spreadsheets and to verify that the spreadsheet equations are functioning properly. The entire Example Field-Set is Locked and Protected to prevent data entry on this sheet. Field-Sets 1, 2, 3 and 4 are used to enter the results from the first, second, third and fourth quarterly RSSCT studies, respectively. Results from both the 10- and 20-minute empty bed contact time (EBCT) runs are entered in the same field-set.

The nine fields in each field-set are identified by the field-set designation (i.e., E, 1, 2, 3, or 4) followed by a field designation (i.e., 1 through 9). For example, Field 1-6 is the sixth field in Field-Set 1, and Field 4-6 is the sixth field in Field-Set 4. Furthermore, fields with the same *field designation* are identical (e.g., Field 1-6 is the same as Field 4-6 except that Field 1-4 is used to report the first set of quarterly results, and Field 4-4 is used to report the fourth set of quarterly results). The field titles, designations and cell ranges are summarized in Table 4-2, and the individual fields are described in Sections 4.1 through 4.9.

4.1 Field 1: PWS And Treatment Plant Data *(A3:B30)*

Field 1 is used to enter the Public Water System (PWS) and treatment plant data, including the PWSID#, plant ICR #, and addresses and phone numbers of the official and technical ICR contacts. Exhibit 4-1 presents an example of Field 1. Some of the information in Field 1 is optional (i.e., the WIDB number and e-mail addresses).

Field Title	Designation	Field Cell Range
PWS and Treatment Plant Data	1	A3:B30
Full-Scale GAC Characteristics	2	D3:E11
RSSCT Design Parameters	3	G3:K43
Pretreatment Used Prior to GAC	4	M3:O24
GAC Influent Water Quality For The 10-Minute EBCT Run	5	Q3:W56
GAC Influent Water Quality For The 20-Minute EBCT Run	6	Y3:AE57
GAC Effluent Water Quality For The 10-Minute EBCT Run	7	AG3:BN46
GAC Effluent Water Quality For The 20-Minute EBCT Run	8	BP3:CW46
GAC Cost Parameters	9	CY3:CZ20

Table 4-2 Summary Of RSSCT Data Fields

4.2 Field 2: Full-Scale GAC Characteristics *(D3:E11)*

Exhibit 4-2 presents an example of Field 2 which is used to enter the characteristics of the GAC used in the RSSCT study, including the carbon manufacturer, the carbon trade name, the carbon type and original GAC mesh size. **The original carbon mesh size entered in this field must be representative of the mesh size used in full-scale contactors** (e.g., 8 x 30, 12 x 40, etc.) since this mesh size is used to calculate the scaling factor (SF) in the RSSCT design. The spreadsheet uses the two US standard mesh sizes entered into this field to calculate the average GAC particle size in millimeters using the ***US Standard Mesh Sizes*** block in Field 3. If the mesh sizes used to report the original carbon size do not appear in this table, it will be necessary to manually calculate the average particle size of the carbon. If the mesh size is not known, but the average particle diameter is known, the diameter in millimeters should be directly entered into the appropriate shaded cell in Field 2, overwriting the equation in this cell. To overwrite an equation in the spreadsheet, the worksheet must be Unprotected and the cell unLocked as described in Section 3.3.

4.3 Field 3: RSSCT Design Parameters *(G3:K43)*

Field 3 uses information input by the user to calculate the design parameters for the RSSCT study, and Exhibit 4-3 presents an example of Field 3. The following parameters must be entered in the first block of this field, ***Input Design Parameters (G4:H12)***, to calculate the RSSCT design parameters:

- An estimate of the influent TOC concentration for a RSSCT study in **mg/L**.

- The inner diameter of the RSSCT column (D_{SC}) in **mm**.
- The minimum Reynolds number for the RSSCT run ($Re_{SC, min}$) (0.5 typical).
- The average annual water temperature at the full-scale plant (T ℃) in **°C**.
- The full-scale bed porosity (ε_{LC}) (0.45 typical).
- The measured dry bed density for the RSSCT column (ρ_{SC}) in **g/cm³**.
- The upper and lower mesh size for the GAC particles used in the RSSCT columns.

In the next block, ***Estimated Run Length (G14:H17)***, the number of bed volumes to 50% TOC breakthrough (BV_{50}) is estimated from the influent TOC concentration. The number of bed volumes for the run (BV_T) is estimated as twice the number of bed volumes for 50% TOC breakthrough. A conservative estimate of the number of bed volumes for the run is obtained by applying a 30% factor of safety to BV_T, and this conservative estimate is used to estimate column run times and feed water volume requirements.

The next block, ***General RSSCT Design Parameters (G19:H25)***, calculates the design parameters common to both RSSCT EBCTs. The kinematic viscosity (ν_{LC}) at the full-scale water temperature is calculated from a non-linear regression valid for temperatures between 0 and 40°C. The average RSSCT carbon particle diameter is calculated from the mesh sizes entered in the first block and the ***US Standard Mesh Sizes (J4:K28)***. If the mesh sizes used in the RSSCT study do not appear in this table, it will be necessary to manually calculate the average carbon particle diameter and enter the value into the appropriate shaded cell in Field 3, overwriting the equation in this cell. To overwrite an equation in the spreadsheet, the worksheet must be Un<u>p</u>rotected and the cell un<u>L</u>ocked as described in Section 3.3. The scaling factor (SF), fluid velocity (v_{SC}) and volumetric flow rate (Q_{SC}) are also calculated in this block. An estimate of the total influent water volume requirements (V_{SC}) is calculated by summing the volumes required for each EBCT run. The volume requirements for each individual EBCT run are calculated in the following blocks.

The last two blocks in this field and, ***10-Minute EBCT Run (G27:H34)*** and ***20-Minute EBCT Run (G36:H43)***, calculate the specific design parameters for the 10- and 20-minute EBCT runs including the actual RSSCT EBCT ($EBCT_{SC}$), an estimate of the RSSCT run time (t_{SC}^T), the required RSSCT bed length (l_{SC}), an estimate of the influent water volume required for the specified EBCT run and the dry mass of GAC required for the RSSCT column (m_{SC}). In both of these blocks, the cell for the full-scale EBCT is not <u>L</u>ocked to allow other EBCTs to be entered if evaluated.

4.4 Field 4: Pretreatment Used Prior To GAC *(M3:O24)*

Exhibit 4-4 presents an example of Field 4 which is used to report all pretreatment processes used prior to the RSSCT columns. All full-scale, pilot-scale and bench-scale pretreatment processes should be listed in this field. The process name should be entered, along with a brief description of the process (e.g., chemical dose, cartridge filter exclusion size, etc.) and the scale of the process (i.e., full-scale, pilot-scale or bench-scale). Detailed design information is not required in this field since these design data will be included in the hard-copy *Treatment Study Summary Report* as described in Section 10.0 of this document. The purpose of Field 4 is to associate the pretreatment processes used during the RSSCT study with the data entered in the spreadsheet.

4.5 Field 5: GAC Influent Water Quality For The 10-Minute EBCT Run *(Q3:W56)*

Exhibit 4-5 presents an example Field 5 which is used to report the water quality of the influent to the 10-minute RSSCT column after the influent batch has undergone all pretreatment processes to be used in the run. The influent water quality parameters are divided into two groups. "Group A" includes alkalinity, total hardness, calcium hardness, ammonia and bromide; and all "Group A" water quality parameters must be sampled twice (2) for each batch of pretreated influent water (i.e. at the beginning and middle of a study). "Group B" includes pH, turbidity, temperature, total organic carbon (TOC), absorbance at ultra-violet 254 nm (UV_{254}), SDS-chlorine demand, SDS-TOX, SDS-THM4 and SDS-HAA6[1]; and all "Group B" water quality parameters must be sampled three (3) times for each batch of pretreated influent water (i.e. at the beginning, middle and end of a study).

Note: A single batch of pretreated influent water must be large enough to conduct at least one RSSCT run at one EBCT. It is advantageous to prepare a single batch of pretreated influent water large enough to run both EBCTs in parallel since this will halve the influent sampling requirements and facilitate comparison of the results from the two EBCT runs.

The date and time at which the 10-minute EBCT run is started must be entered in the appropriate cells at the top of Field 5 ***(R5:R6)***. The starting date and time are used to calculate the operation time at which samples were collected throughout the 10-minute EBCT run. The date and time at which each influent sample was collected must also be entered in the appropriate cells in Field 5. The spreadsheet calculates the operation time (in decimal hours) when the sample was collected as the difference between the sample collection date/time and the start date/time. The number of bed volumes passed through the column at the time of sampling is calculated by dividing the operation time by the actual RSSCT EBCT.

Note: If the system was shut-down for a significant period of time (e.g., more than 15 minutes), the spreadsheet will not calculate the accurate operation time. If this is the case, the operation time must be manually calculated and entered into the spreadsheet, overwriting the automatic calculation. To overwrite an equation in the spreadsheet, the sheet must be Unprotected and the cell unLocked as described in Section 3.3.

Field 5 calculates the arithmetic average and the relative percent difference (RPD) or percent standard deviation (%SD) for each influent water quality parameter. This field also calculates SUVA, SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

4.6 Field 6: GAC Influent Water Quality For The 20-Minute EBCT Run *(Y3:AE57)*

Field 6 is identical to Field 5 except that it is used to report the water quality of the influent to the 20-minute RSSCT column after the influent batch has undergone all pretreatment

[1]Only six HAA species are required, but the additional three HAA species (TBAA, CDBAA and DCBAA) should be reported if measured.

processes. If the same batch of influent is used for both the 10- and the 20-minute EBCT runs, simply enter the same data in Fields 5 and 6; **however, the starting date and time entered in cells *Z5:Z6* of Field 6 must represent the date/time at which the 20-minute EBCT run was started.** The starting date and time are used to calculate the operation time at which samples were collected throughout the 20-minute EBCT run.

4.7 Field 7: GAC Effluent Water Quality For The 10-Minute EBCT Run *(AG3:BN46)*

Field 7 is used to report the effluent water quality for the 10-minute RSSCT run as a function of operation time, and an example of Field 7 is shown in Exhibit 4-6. Twelve (12) effluent samples are to be analyzed for the "Group C" water quality parameters which include: pH, temperature, TOC, UV_{254}, SDS-chlorine demand, SDS-TOX, SDS-THM4 and SDS-HAA6. Additionally, the "Group C" water quality analyses must be duplicated for three (3) effluent samples, and the duplicate water quality samples are designated as "Group D."

In the first block ***(AG4:BN27)***, the results from the twelve water quality analyses are entered, and five extra rows are provided so that additional results can be reported if measured. The second column of the first block of Field 7 is used to designate whether or not a sample was duplicated. The results of duplicate samples are not entered into the first block of Field 7; instead the results from the *primary* and *duplicate* analyses are entered in the second block of Field 7 ***(AG29:BN46)***. The second block calculates the average and relative percent difference for the primary and duplicate analyses. Then the average results from the primary and duplicate analyses must be entered in the appropriate rows of the first block of Field 7. For example, Exhibit 4-6 indicates that sample C3-10 was duplicated, so the results of the primary and duplicate analyses are entered into the second block of Field 7 where the average and relative percent difference are calculated. Then the average value (Avg-C3-10) for the primary (C3-10) and duplicate (D-C3-10) analyses is entered in the appropriate row of the first block. Field 7 also calculates SUVA, SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

The date and *average* time at which each effluent sample was collected must be entered in Field 7. The spreadsheet calculates the average operation time (in decimal hours) when the sample was collected as the difference between the sample collection date/average time and the start date/time. (Note that the start date/time for the 10-minute EBCT is entered in Field 5.) The number of bed volumes passed through the column at the time of sampling is calculated by dividing the operation time by the RSSCT EBCT.

Note: If the system was shut-down for a significant period of time (e.g., more than 15 minutes), the spreadsheet will not calculate an accurate operation time. If this is the case, the operation time must be manually calculated and entered into the spreadsheet, overwriting the automatic calculation. To overwrite an equation in the spreadsheet, the worksheet must be Unprotected and the cell unLocked as described in Section 3.3.

4.8 Field 8: GAC Effluent Water Quality For The 20-Minute EBCT Run *(BP3:CW46)*

Field 8 is identical to Field 7 except that it is used to report the effluent water quality for the 20-minute EBCT as a function of operation time. The spreadsheet calculates the average operation time (in decimal hours) when the sample was collected as the difference between the sample collection date/average time and the start date/time. (Note that the start date/time for the 20-minute EBCT is entered in Field 6.) Field 8 also calculates the bed volumes passed at the time of sampling, as well as SUVA, SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

4.9 Field 9: GAC Cost Parameters *(CY3:CZ20)*

Field 9 is used to report the utility-specific cost parameters that are used to generate cost estimates for the use of GAC technology, and an example of Field 9 is shown in Exhibit 4-7. Example cost parameters are listed in Exhibit 4-7, but it is important to report cost parameters specific to the utility and not default or example values.

	A	B
3	**Field E-1: PWS And Treatment Plant Data**	
4		
5	PWS Name	Anytown Public Works
6	Public Water System Identification Number	OH1234567
7	Water Industry Data Base Number (*optional*)	######
8		
9	Official ICR Contact Person	Mr. Any Body
10	Mailing Address	#### Street
11		City, State Zip code
12	Phone Number	(###) ###-####
13	FAX Number	(###) ###-####
14	E-Mail Address (*optional*)	last.first@wtp.com
15		
16	Technical ICR Contact Person	Ms. Some One
17	Mailing Address	#### Street
18		City, State Zip code
19	Phone Number	(###) ###-####
20	FAX Number	(###) ###-####
21	E-Mail Address (*optional*)	last.first@wtp.com
22		
23	Plant Name	East WTP
24	Treatment Plant Category	CONV
25	Process Train Name	Conventional train
26	ICR Treatment Plant Identification Number	###
27	PWSID Number of Plant (*if assigned*)	Not assigned
28	Historical Minimum Water Temperature (°C)	4.0
29	Historical Average Water Temperature (°C)	18.0
30	State Approved Plant Capacity (MGD)	100.0
31		
32	**Exhibit 4-1 Example Of Field 1 For The RSSCT Data Sheet**	
33		

	D	E
3	**Field E-2: Full-Scale GAC Characteristics[1]**	
4		
5	Carbon manufacturer	Company Name
6	Carbon trade name	GAC-123
7	Carbon type	Bituminous coal based
8	Original GAC mesh size, upper (US standard mesh)	12
9	Original GAC mesh size, lower (US standard mesh)	40
10	Original carbon particle diameter, d_{LC} (mm)	1.053
11	1: These are the characteristics before the carbon is ground for RSSCT experiments.	
12		
13	**Exhibit 4-2 Example Of Field 2 For The RSSCT Data Sheet**	

	G	H	I	J	K
3	**Field E-3: RSSCT Design Parameters**				
4	***Input Design Parameters***			***US Standard Mesh Sizes***	
5	RSSCT influent TOC (mg/L)	4.2		US standard mesh size	Opening (mm)
6	Inner diameter of the RSSCT column, D_{SC} (mm)	8.0			
7	Minimum RSSCT Reynolds number, $Re_{SC,\ min}$	0.5		4	4.750
8	Full-scale operating temperature, T^oC (^oC)	21.0		6	3.350
9	Full-scale bed porosity, ε_{LC}	0.45		8	2.360
10	Measured RSSCT dry bed density, ρ_{SC} (g/cm^3)	0.49		10	2.000
11	RSSCT GAC mesh size, upper (US standard mesh)	100		12	1.680
12	RSSCT GAC mesh size, lower (US standard mesh)	200		16	1.180
13				20	0.850
14	***Estimated Run Length***			30	0.600
15	Bed volumes to 50% TOC breakthrough, BV_{50}	3359		40	0.425
16	Estimated run length, BV_T (= 2 x BV_{50})	6718		50	0.300
17	BV_T + 30% safety factor, $BV_{T+30\%}$ (= 2.6 x BV_{50})	8734		60	0.250
18				70	0.210
19	***General RSSCT Design Parameters***			80	0.180
20	Kinematic viscosity at T^oC, ν_{LC} (m^2/s)	1.001E-06		100	0.150
21	RSSCT carbon particle diameter, d_{SC} (mm)	0.1125		120	0.125
22	Scaling factor, SF	9.36		140	0.106
23	RSSCT hydraulic loading rate, v_{SC} (m/hr)	7.21		170	0.088
24	RSSCT flow rate, Q_{SC} (mL/min)	6.04		200	0.075
25	Estimated total influent volume required, V_{SC}^T (L)	169		230	0.062
26				270	0.053
27	***10-Minute EBCT Run***			325	0.044
28	Full-scale empty bed contact time, $EBCT_{LC}$ (min)	10		400	0.037
29	Estimated full-scale run time, t_{LC}^T (days)	61			
30	RSSCT empty bed contact time, $EBCT_{SC}$ (min)	1.07			
31	Estimated RSSCT run time, t_{SC}^T (days)	6.48			
32	RSSCT bed length, l_{SC} (cm)	12.8			
33	Estimated volume required for 10-minute EBCT, V_{SC} (L)	56			
34	Mass GAC required, m_{SC} (g)	3.16			
35					
36	***20-Minute EBCT Run***				
37	Full-scale empty bed contact time, $EBCT_{LC}$ (min)	20			
38	Estimated full-scale run time, t_{LC}^T (days)	121			
39	RSSCT empty bed contact time, $EBCT_{SC}$ (min)	2.14			
40	Estimated RSSCT run time, t_{SC}^T (days)	12.97			
41	RSSCT bed length, l_{SC} (cm)	25.7			
42	Estimated volume required for 20-minute EBCT, V_{SC} (L)	113			
43	Mass GAC required, m_{SC} (g)	6.32			
44					
45	**Exhibit 4-3 Example Of Field 3 For The RSSCT Data Sheet**				

	M	N	O
3	**Field E-4: Pretreatment Used Prior To GAC**[1]		
4			
5	**Process**	**Description**	**Scale**
6	Coagulation	50 ± 15 mg/L alum	Full-Scale
7	Flocculation	2-stage	Full-Scale
8	Sedimentation	tube settler	Full-Scale
9	Dual media filtration	sand / anthracite	Full-Scale
10	Cartridge filtration	2 um exclusion size	Bench-scale
11	Sulfuric acid addition	pH = 6.0	Bench-scale
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22	1: Design information, similar to that shown in Tables 6c and 6d of the ICR rule, must be included in		
23	the hard-copy *Treatment Study Summary Report* (see Section 10.0). The purpose of this table		
24	is to list the pretreatment processes used in this particular RSSCT run.		
25			
26	**Exhibit 4-4 Example Of Field 4 For The RSSCT Data Sheet**		

	Q	R	S	T	U	V	W
3	**Field E-5: GAC Influent Water Quality For The 10-Minute EBCT Run**						
4							
5	**10-min. EBCT Start Date**	4/11/96					
6	**10-min. EBCT Start Time**	10:30					
7							
8	***Group A, 2 samples per batch***						
9	**Parameter**	**Units**	**Sample A1-10**	**Sample A2-10**	**Average**	**RPD**	
10	Sampling date	MM/DD/YY	4/11/96	4/16/96	---	---	
11	Sampling time	hh:mm	11:30	7:22	---	---	
12	Operation time	hh.hh	1.00	116.87	---	---	
13	Bed volumes	(10 minutes)	56.1	6560.1	---	---	
14	Alkalinity	mg/L as $CaCO_3$	75.0	70.0	72.5	6.90	
15	Total hardness	mg/L as $CaCO_3$	320.0	309.0	314.5	3.50	
16	Calcium hardness	mg/L as $CaCO_3$	291.0	288.0	289.5	1.04	
17	Ammonia	mg NH_3-N / L	4.2	4.6	4.4	9.09	
18	Bromide	µg/L	102.0	99.0	100.5	2.99	
19							
20	***Group B, 3 samples per batch***						
21	**Parameter**	**Units**	**Sample B1-10**	**Sample B2-10**	**Sample B3-10**	**Average**	**%SD**
22	Sampling date	MM/DD/YY	4/11/96	4/16/96	4/20/96	---	---
23	Sampling time	hh:mm	11:30	7:22	21:00	---	---
24	Operation time	hh.hh	1.00	116.87	226.50	---	---
25	Bed volumes	(10 minute)	56.1	6560.1	12714.2	---	---
26	pH	---	6.00	5.80	6.10	5.97	2.56
27	Turbidity	ntu	0.80	1.00	1.20	1.00	20.00
28	Temperature	^oC	22.0	24.0	23.0	23.0	4.35
29	Total organic carbon	mg/L	4.10	3.95	4.12	4.06	2.29
30	UV_{254}	cm^{-1}	0.143	0.155	0.147	0.148	4.12
31	SUVA	L/(mg*m)	3.49	3.92	3.57	3.66	6.34
32	SDS-Cl_2 dose	mg/L	4.20	4.40	4.30	4.30	2.33
33	SDS-Free Cl_2 residual	mg/L	0.95	1.10	1.05	1.03	7.39
34	SDS-Cl_2 demand	mg/L	3.25	3.30	3.25	3.27	0.88
35	SDS-Chlorination temp.	^oC	19.8	20.4	20.2	20.1	1.52
36	SDS-Chlorination pH	---	7.95	7.98	8.02	7.98	0.44
37	SDS-Incubation time	hours	89.3	89.2	89.1	89.2	0.11
38	SDS-TOX	µg Cl^-/L	385.00	372.00	382.00	379.67	1.79
39	SDS-*CHCl3*	µg/L	75.00	77.00	74.00	75.33	2.03
40	SDS-*BDCM*	µg/L	21.10	19.80	18.70	19.87	6.05
41	SDS-*DBCM*	µg/L	4.60	4.50	4.50	4.53	1.27
42	SDS-*CHBr3*	µg/L	BMRL	BMRL	BMRL	#DIV/0!	#DIV/0!
43	SDS-THM4	µg/L	100.70	101.30	97.20	99.73	2.22
44	SDS-*MCAA**	µg/L	2.50	2.80	2.30	2.53	9.93
45	SDS-*DCAA**	µg/L	15.40	14.80	16.20	15.47	4.54
46	SDS-*TCAA**	µg/L	25.30	27.00	26.70	26.33	3.45
47	SDS-*MBAA**	µg/L	BMRL	0.67	0.80	0.74	12.51
48	SDS-*DBAA**	µg/L	2.58	1.96	2.41	2.32	13.83
49	SDS-*BCAA**	µg/L	16.50	17.20	16.80	16.83	2.09
50	SDS-*TBAA*	µg/L	NA	NA	NA	#DIV/0!	#DIV/0!
51	SDS-*CDBAA*	µg/L	NA	NA	NA	#DIV/0!	#DIV/0!
52	SDS-*DCBAA*	µg/L	NA	NA	NA	#DIV/0!	#DIV/0!
53	SDS-HAA5	µg/L	45.78	47.23	48.41	47.14	2.79
54	SDS-HAA6	µg/L	62.28	64.43	65.21	63.97	2.37
55	BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported						
56	*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.						
57							
58	**Exhibit 4-5 Example Of Field 5 For The RSSCT Data Sheet**						

	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV

3 **Field E-7: GAC Effluent Water Quality For The 10-Minute EBCT Run[1]**

4 ***Group C, 12 effluent samples per run***

5/6/7	Sample ID	Was sample duplicated? Y/N	Sampling date MM/DD/YY	Sampling time hh:mm	Operation time hh.hh	Bed volumes (10 minute)	pH ---	Temp. °C	TOC mg/L	UV_{254} cm^{-1}	SUVA L/(mg*m)	SDS Cl_2 dose mg/L	SDS Free Cl_2 residual mg/L	SDS Cl_2 demand mg/L	SDS Chlorination temp. °C	SDS Chlorination pH ---
8	**C1-10**	N	4/11/96	11:30	1.00	56.1	6.00	22.0	0.26	0.003	1.15	1.32	0.95	0.37	20.2	7.95
9	**C2-10**	N	4/11/96	19:00	8.50	477.1	5.90	24.0	0.51	0.007	1.37	1.40	1.02	0.38	20.1	8.02
10	**Avg-C3-10**	Y	4/12/96	4:30	18.00	1010.4	6.00	25.0	0.77	0.012	1.56	1.50	1.05	0.45	19.9	8.05
11	**C4-10**	N	4/12/96	12:30	26.00	1459.5	6.00	23.0	0.98	0.019	1.94	1.75	1.10	0.65	20.0	8.05
12	**C5-10**	N	4/12/96	21:30	35.00	1964.7	6.10	22.0	1.22	0.027	2.21	2.07	1.00	1.07	20.4	7.92
13	**C6-10**	N	4/13/96	7:00	44.50	2497.9	5.80	22.5	1.49	0.040	2.68	2.41	0.90	1.51	20.3	8.00
14	**Avg-C7-10**	Y	4/13/96	16:00	53.50	3003.1	5.80	24.0	1.75	0.045	2.57	2.80	1.10	1.70	20.0	8.01
15	**C8-10**	N	4/14/96	1:30	63.00	3536.4	5.90	24.0	2.06	0.057	2.77	3.24	1.08	2.16	19.8	7.94
16	**C9-10**	N	4/14/96	13:30	75.00	4210.0	6.10	24.5	2.22	0.065	2.93	3.58	0.95	2.63	19.7	8.06
17	**C10-10**	N	4/15/96	3:30	89.00	4995.9	6.10	25.0	2.50	0.081	3.24	3.87	0.95	2.92	20.2	8.02
18	**Avg-C11-10**	Y	4/15/96	17:00	102.50	5753.7	6.20	22.0	2.78	0.091	3.27	4.06	1.03	3.03	19.8	8.01
19	**C12-10**	N	4/16/96	7:22	116.87	6560.1	6.00	21.5	3.08	0.098	3.18	4.31	1.00	3.31	20.1	7.98
20					-843994.50	-47376224.6					#DIV/0!			0.00		
21					-843994.50	-47376224.6					#DIV/0!			0.00		
22					-843994.50	-47376224.6					#DIV/0!			0.00		
23					-843994.50	-47376224.6					#DIV/0!			0.00		
24					-843994.50	-47376224.6					#DIV/0!			0.00		

25 BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

26 *: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

27 1: Do not enter the results from duplicate samples into the table above, instead enter the average value for the primary and duplicate analyses in the above table, and enter the results for the primary and duplicate analyses below.

28

29 ***Group D, 3 duplicate effluent samples per run (results from primary and duplicate analyses)***

30/31/32	Sample ID	Sample Type	Sampling date MM/DD/YY	Sampling time hh:mm	Operation time hh.hh	Bed volumes (10 minute)	pH ---	Temp. °C	TOC mg/L	UV_{254} cm^{-1}	SUVA L/(mg*m)	SDS Cl_2 dose mg/L	SDS Free Cl_2 residual mg/L	SDS Cl_2 demand mg/L	SDS Chlorination temp. °C	SDS Chlorination pH ---
33	**C3-10**	Primary	4/12/96	4:30	18.00	1010.4	5.90	25.0	0.80	0.010	1.25	1.40	1.10	0.30	19.9	8.07
34	**D-C3-10**	Duplicate	4/12/96	4:30	18.00	1010.4	6.10	25.0	0.73	0.014	1.92	1.60	1.00	0.60	19.9	8.03
35	**Avg-C3-10**	Average	---	---	---	---	6.00	25.0	0.77	0.012	1.58	1.50	1.05	0.45	19.9	8.05
36	**RPD-C3-10**	RPD	---	---	---	---	3.33	0.00	9.15	33.33	42.16	13.33	9.52	66.67	0.00	0.50
37	**C7-10**	Primary	4/13/96	16:00	53.50	3003.1	6.10	24.0	1.70	0.047	2.76	2.90	1.15	1.75	20.0	8.00
38	**D-C7-10**	Duplicate	4/13/96	16:00	53.50	3003.1	5.90	24.0	1.80	0.043	2.39	2.70	1.05	1.65	20.0	8.02
39	**Avg-C7-10**	Average	---	---	---	---	6.00	24.0	1.75	0.045	2.58	2.80	1.10	1.70	20.0	8.01
40	**RPD-C7-10**	RPD	---	---	---	---	3.33	0.00	5.71	8.89	14.58	7.14	9.09	5.88	0.00	0.25
41	**C11-10**	Primary	4/15/96	17:00	102.50	5753.7	6.00	22.0	2.83	0.095	3.36	4.10	1.06	3.04	19.8	8.02
42	**D-C11-10**	Duplicate	4/15/96	17:00	102.50	5753.7	6.40	22.0	2.72	0.087	3.20	4.02	1.00	3.02	19.8	8.00
43	**Avg-C11-10**	Average	---	---	---	---	6.20	22.0	2.78	0.091	3.28	4.06	1.03	3.03	19.8	8.01
44	**RPD-C11-10**	RPD	---	---	---	---	6.45	0.00	3.96	8.79	4.83	1.97	5.83	0.66	0.00	0.25

45 BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

46 *: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

47

48 **Exhibit 4-6 Example Of Field 7 For The RSSCT Data Sheet (page 1 of 2)**

	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN
3	**Field E-7: GAC Effluent Water Quality For The 10-Minute EBCT Run (continued)**																	
4																		
5	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**
6	**Incubation time**	**TOX**	***CHCl3***	***BDCM***	***DBCM***	***CHBr3***	**THM4**	***MCAA****	***DCAA****	***TCAA****	***MBAA****	***DBAA****	***BCAA****	***TBAA***	***CDBAA***	***DCBAA***	**HAA5**	**HAA6**
7	hours	µg Cl^- /L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
8	88.5	33.00	6.55	1.73	0.39	BMRL	8.67	BMRL	1.35	2.29	BMRL	BMRL	1.46	NA	NA	NA	3.63	5.09
9	88.6	38.50	7.64	2.02	0.46	BMRL	10.12	0.26	1.57	2.67	BMRL	BMRL	1.71	NA	NA	NA	4.49	6.20
10	88.8	44.00	8.73	2.30	0.53	BMRL	11.56	BMRL	1.79	3.05	BMRL	0.27	1.95	NA	NA	NA	5.11	7.06
11	88.2	68.20	13.53	3.57	0.81	0.10	18.02	0.45	2.78	4.72	0.13	0.42	3.02	NA	NA	NA	8.51	11.54
12	87.6	97.90	19.43	5.13	1.17	0.14	25.87	0.65	3.99	6.78	0.19	BMRL	4.34	NA	NA	NA	11.62	15.96
13	87.0	143.00	28.38	7.49	1.71	0.21	37.78	0.95	5.83	9.91	0.28	0.87	6.34	NA	NA	NA	17.85	24.19
14	87.2	176.00	34.93	9.22	2.10	0.26	46.50	1.17	7.17	12.19	0.35	1.08	7.81	NA	NA	NA	21.96	29.77
15	86.9	220.00	43.66	11.52	2.63	0.32	58.12	1.47	8.97	15.24	0.43	1.34	9.76	NA	NA	NA	27.46	37.21
16	87.4	271.00	53.70	14.17	3.23	0.39	71.49	1.80	11.03	18.75	0.53	1.65	12.00	NA	NA	NA	33.77	45.77
17	87.1	314.00	62.22	16.41	3.74	0.45	82.83	2.09	12.78	21.72	0.62	1.92	13.90	NA	NA	NA	39.12	53.03
18	88.0	327.00	64.84	17.11	3.90	0.47	86.31	2.18	13.32	22.63	0.65	2.00	14.49	NA	NA	NA	40.77	55.26
19	87.6	352.00	69.86	18.43	4.20	0.51	93.00	2.35	14.35	24.39	0.70	2.15	15.61	NA	NA	NA	43.93	59.54
20							0.00										0.00	0.00
21							0.00										0.00	0.00
22							0.00										0.00	0.00
23							0.00										0.00	0.00
24							0.00										0.00	0.00
25	BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported																	
26	*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.																	
27																		
28																		
29																		
30	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**
31	**Incubation time**	**TOX**	***CHCl3***	***BDCM***	***DBCM***	***CHBr3***	**THM4**	***MCAA****	***DCAA****	***TCAA****	***MBAA****	***DBAA****	***BCAA****	***TBAA***	***CDBAA***	***DCBAA***	**HAA5**	**HAA6**
32	hours	µg Cl^- /L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
33	88.9	46.00	8.80	2.40	0.53	BMRL	11.73	BMRL	1.81	3.00	BMRL	0.27	2.00	NA	NA	NA	5.08	7.08
34	88.7	42.00	8.65	2.20	0.53	BMRL	11.38	BMRL	1.77	3.10	BMRL	0.27	1.90	NA	NA	NA	5.14	7.04
35	88.8	44.00	8.73	2.30	0.53	#DIV/0!	11.56	#DIV/0!	1.79	3.05	#DIV/0!	0.27	1.95	#DIV/0!	#DIV/0!	#DIV/0!	5.11	7.06
36	0.23	9.09	1.72	8.70	0.00	#VALUE!	3.03	#VALUE!	2.23	3.28	#VALUE!	0.00	5.13	#VALUE!	#VALUE!	#VALUE!	1.17	0.57
37	87.3	180.00	35.01	9.44	2.00	0.27	46.72	1.21	7.25	12.24	0.35	1.13	7.91	NA	NA	NA	22.18	30.09
38	87.1	172.00	34.85	9.00	2.20	0.25	46.30	1.13	7.09	12.14	0.35	1.03	7.71	NA	NA	NA	21.74	29.45
39	87.2	176.00	34.93	9.22	2.10	0.26	46.51	1.17	7.17	12.19	0.35	1.08	7.81	#DIV/0!	#DIV/0!	#DIV/0!	21.96	29.77
40	0.23	4.55	0.46	4.77	9.52	7.69	0.90	6.84	2.23	0.82	0.00	9.26	2.56	#VALUE!	#VALUE!	#VALUE!	2.00	2.15
41	88.0	330.00	65.00	17.21	4.00	0.47	86.68	2.20	13.42	22.73	0.70	2.50	14.75	NA	NA	NA	41.55	56.30
42	88.0	324.00	64.68	17.00	3.80	0.47	85.95	2.16	13.22	22.53	0.60	1.50	14.23	NA	NA	NA	40.01	54.24
43	88.0	327.00	64.84	17.11	3.90	0.47	86.32	2.18	13.32	22.63	0.65	2.00	14.49	#DIV/0!	#DIV/0!	#DIV/0!	40.78	55.27
44	0.00	1.83	0.49	1.23	5.13	0.00	0.85	1.83	1.50	0.88	15.38	50.00	3.59	#VALUE!	#VALUE!	#VALUE!	3.78	3.73
45	BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported																	
46	*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.																	
47																		
48	**Exhibit 4-6 Example Of Field 7 For The RSSCT Data Sheet (page 2 of 2)**																	

	CY	CZ
3	**Field E-9: GAC Cost Parameters**	
4		
5	**Cost Parameter**	**Parameter value**
6	Capital Recovery Interest Rate (%)	10
7	Capital Recovery Period (years)	20
8	Overhead & Profit Factor (% of construction costs)	5
9	Special Sitework Factor (% of construction costs)	5
10	Construction Contingencies (% of construction costs)	10
11	Engineering Fee Factor (% of construction costs)	10
12	1998 ENR Construction Cost Index (CCI base year 1913)	####
13	1998 Producers Price Index (PPI base year 1967 = 100)	###
14	Labor Rate + Fringe ($/work-hour)	15
15	Labor Overhead Factor (% of labor)	10
16	Electric Rate ($/kW-h)	0.086
17	Fuel Oil Rate ($/gal)	0.89
18	Natural Gas Rate ($/ft^3)	0.0055
19	Current Process Water Rate ($/1000 gal)	0.35
20	Modifications to Existing Plant (% of construction costs)	5
21		
22	**Exhibit 4-7 Example Of Field 9 For The RSSCT Data Sheet**	

Appendix 4a: GAC RSSCT Equations And Nomenclature

<u>**Nomenclature**</u>

BCAA	Bromochloroacetic acid **(μg/L)**
BDCAA	Bromodichloroacetic acid **(μg/L)**
BDCM	Bromodichloromethane **(μg/L)**
BMRL	Below minimum reporting level
$\mathbf{BV_{50}}$	Estimated number of bed volumes to 50% TOC breakthrough
$\mathbf{BV_{T}}$	Estimated total number of bed volumes over the run
$\mathbf{BV_{T+30\%}}$	Estimated total number of bed volumes over the run with 30% factor of safety
CHBr3	Bromoform **(μg/L)**
CHCl3	Chloroform **(μg/L)**
$\mathbf{d_{LC}}$	Original, or typical, carbon particle diameter used in full-scale columns **(mm)**
$\mathbf{d_{SC}}$	Carbon particle diameter used in RSSCT columns **(mm)**
$\mathbf{D_{SC}}$	Inner diameter of the RSSCT column **(mm)**
DBAA	Dibromoacetic acid **(μg/L)**
DBCAA	Dibromochloroacetic acid **(μg/L)**
DBCM	Dibromochloromethane **(μg/L)**
DCAA	Dichloroacetic acid **(μg/L)**
$\mathbf{EBCT_{LC}}$	Full-scale empty bed contact time **(min)**
$\mathbf{EBCT_{SC}}$	RSSCT empty bed contact time **(min)**
$\mathbf{l_{SC}}$	RSSCT carbon bed length **(cm)**
$\mathbf{m_{SC}}$	Mass of carbon required for a RSSCT column **(g)**
MBAA	Monobromoacetic acid **(μg/L)**
MCAA	Monochloroacetic acid **(μg/L)**
NA	Not analyzed
NR	Not reported
$\mathbf{Q_{SC}}$	Volumetric flow rate for the RSSCT **(mL/min)**
$\mathbf{Re_{SCmin}}$	Minimum Reynolds number for the RSSCT column, 0.5 typical
SDS	Simulated distribution system
SDS-CD	SDS chlorine demand **(mg/L)**
SDS-Cl Dose	SDS chlorine dose **(mg/L)**
SDS-CR	SDS free chlorine residual **(mg/L)**
SDS-HAA5	The sum of five haloacetic acids evaluated under SDS conditions **(μg/L)**
SDS-HAA6	The sum of six haloacetic acids evaluated under SDS conditions **(μg/L)**
SDS-THM4	The sum of four trihalomethanes evaluated under SDS conditions **(μg/L)**
SDS-TOX	Total organic halides evaluated under SDS conditions **(μg Cl^-/L)**
SF	Scaling factor for RSSCT design
SUVA	Specific ultraviolet absorbance **(L/(mg*m))**
T°C	Full-scale water temperature **(°C)**
$\mathbf{t_{LC}^{T}}$	Estimated full-scale run time **(days)**
$\mathbf{t_{SC}^{T}}$	Estimated RSSCT time **(days)**
TBAA	Tribromoacetic acid **(μg/L)**
TCAA	Trichloroacetic acid **(μg/L)**

TOC	Total organic carbon **(mg/L)**
TOC_I	Influent TOC **(mg/L)**
UV_{254}	Ultra-violet absorbance at 254 nm **(cm^{-1})**
v_{SC}	Superficial velocity or hydraulic loading rate for the RSSCT column **(m/hr)**
V_{SC}	Estimate of water volume required for RSSCT run **(L)**
ε_{LC}	Bed porosity
ν_{LC}	Kinematic viscosity **(m^2/s)**
ρ_{SC}	Measured dry bed density **(g/cm^3)**

RSSCT DESIGN CALCULATIONS

Average Full-Scale Carbon Particle Diameter (Example cell: E10)

$$\mathbf{d_{LC} = (Full\text{-}scale\ upper\ mesh\ diameter + Full\text{-}scale\ lower\ mesh\ diameter) / 2} \qquad \textbf{(4a.1)}$$

Note: The upper and lower mesh diameters are determined from the Standard US Mesh Sizes listed in cell block J4:K28.

Bed Volumes To 50% TOC Breakthrough (Example cell: H15)

$$\mathbf{BV_{50} = 21{,}700 \times TOC_I^{-1.3}} \qquad \textbf{(4a.2)}$$

Estimated Run Length In Bed Volumes (Example cell: H16)

$$\mathbf{BV_T = 2 \times BV_{50}} \qquad \textbf{(4a.3)}$$

Estimated Column Run Time with 30% Factor of Safety (Example cell: H17)

$$\mathbf{BV_{T+30\%} = 2.6 \times BV_{50}} \qquad \textbf{(4a.4)}$$

Estimated Kinematic Viscosity Of Water (Example cell: H20)

$$\nu_{LC} \approx \mathbf{7.95 \times 10^{-10} \times exp(2100/(273.15 + T°C))} \qquad \textbf{(4a.5)}$$

Average RSSCT Carbon Particle Diameter (Example cell: H21)

$$\mathbf{d_{SC} = (RSSCT\ upper\ mesh\ diameter + RSSCT\ lower\ mesh\ diameter) / 2} \qquad \textbf{(4a.6)}$$

Note: The upper and lower mesh diameters are determined from the Standard US Mesh Sizes listed in cell block J4:K28.

Scaling Factor (Example cell: H22)

$$\mathbf{SF = d_{LC} / d_{SC}} \qquad \textbf{(4a.7)}$$

Hydraulic Loading Rate For RSSCT Column (Example cell: H23)

$$\mathbf{v_{SC} = (Re_{SCmin} \times \nu_{LC} \times \varepsilon_{LC} \times 3600) / (d_{SC} / 1000)} \qquad \textbf{(4a.8)}$$

Flow Rate For RSSCT Column (Example cell: H24)

$$\mathbf{Q_{SC} = (v_{SC} \times 100 / 60) \times (\pi / 4) \times (D_{SC} / 10)^2} \qquad \textbf{(4a.9)}$$

Estimated Full-Scale Run Time (Example cells: H29, H38)

$$\mathbf{t_{LC}^{T} = (BV_T \times EBCT_{LC}) / (60 \times 24)} \qquad \textbf{(4a.10)}$$

RSSCT Empty Bed Contact Time (Example cells: H30, H39)

$$\mathbf{EBCT_{SC} = EBCT_{LC} / SF} \qquad \textbf{(4a.11)}$$

Estimated RSSCT Column Run Time (Example cells: H31, H40)

$$\mathbf{t_{SC}^{T} = t_{LC}^{T} / SF} \qquad \textbf{(4a.12)}$$

RSSCT Carbon Bed Length (Example cells: H32, H41)

$$\mathbf{l_{SC} = v_{SC} \times EBCT_{SC} \times 100 / 60} \qquad \textbf{(4a.13)}$$

Estimated Volume Required For A RSSCT Column Run (Example cells: H33, H42)

$$\mathbf{V_{SC} = Q_{SC} \times t_{SC}^{T} \times 24 \times 60 / 1000} \qquad \textbf{(4a.14)}$$

Mass Of GAC Required For A RSSCT Column (Example cells: H34, H43)

$$\mathbf{m_{SC} = (\rho_{SC} \times l_{SC}) \times (\pi /4) \times (D_{SC} / 10)^2} \qquad \textbf{(4a.15)}$$

Bed Volumes (Example cells: S13:T13, S25:U25, AL8:AL42, BU8:BU42)

$$\mathbf{BV = Operation\ time / EBCT_{SC}} \qquad \textbf{(4a.16)}$$

<u>Water Quality Analysis</u>

SDS-Chlorine Demand (Example cells: S34:U34, AA34:AC34, AT8:AT42, CC8:CC42)

$$\mathbf{(SDS\text{-}CD) = (SDS\text{-}Cl\ Dose) - (SDS\text{-}CR)} \qquad \textbf{(4a.17)}$$

SDS-HAA5 (Example cells: S53:U53, AA53:AC53, BM8:BM42, CV8:CV42)

$$\mathbf{SDS\text{-}HAA5 = MCAA + DCAA + TCAA + MBAA + DBAA} \qquad \textbf{(4a.18)}$$

SDS-HAA6 (Example Cells: S54:U54, AA54:AC54, BN8:BN42, CW8:CW42)

$$\mathbf{SDS\text{-}HAA6 = MCAA + DCAA + TCAA + MBAA + DBAA + BCAA} \qquad \textbf{(4a.19)}$$

SDS-THM4 (Example cells: S43:U43, AA43:AC43, BC8:BC42, CL8:CL42)

$$\mathbf{SDS\text{-}THM4 = CHCl3 + BDCM + DBCM + CHBr3} \qquad \textbf{(4a.20)}$$

Specific UV_{254} (Example cells: S31:U31, AA31:AC31, AQ8:AQ42, BZ8:BZ42)

$$\mathbf{SUVA = (UV_{245}/TOC) \times 100 (cm/m)} \qquad \textbf{(4a.21)}$$

5.0 Spreadsheet For GAC Pilot-Scale Studies

The spreadsheet for pilot-scale GAC studies (*gacpilot.xls)* is designed to contain the data from two pilot-scale GAC studies, with each study consisting of a 10- and 20-minute EBCT run. This spreadsheet consists of three (3) field-sets with seven (7) fields in each set. Each field-set is located on a separate worksheet, and Table 5-1 summarizes the designation, sheet titles and cell range for each field-set.

Field-Set Title (Designation)	Sheet Title	Field-Set Cell Range
Example Pilot-Scale GAC Data (E-)	Sheet0. Example Data	A1:DZ55
Results From 1st Pilot-Scale Study (1-)	Sheet1. 1st Pilot Study	A1:DZ55
Results From 2nd Pilot-Scale Study (2-)	Sheet2. 2nd Pilot Study	A1:DZ55

Table 5-1 Summary Of Pilot-Scale GAC Field-Sets And Corresponding Sheet Titles

The Example Field-Set (Fields E-1 to E-7) demonstrates the use of the pilot GAC spreadsheet. Example data are presented in each field to clarify the use of the spreadsheet and to verify that the spreadsheet equations are functioning properly. The entire Example Field-Set is Locked and Protected to prevent data entry on this worksheet. Field-Set 1 is used to enter the results from the first pilot-scale GAC study, and Field-Set 2 is used to enter the results from the second pilot-scale study (if a second pilot study is required). Results from both the 10- and 20-minute empty bed contact times (EBCTs) are entered in the appropriate fields in each field-set.

The seven fields in each field-set are identified by the field-set designation (i.e., E, 1, or 2) followed by a field designation (i.e., 1 through 7). For example, Field 1-6 is the sixth field in Field-Set 1, and Field 2-6 is the sixth field in Field-Set 2. Furthermore, fields with the same *field designation* are identical (e.g., Field 1-6 is the same as Field 2-6 except that Field 1-6 is used to report results from the first pilot GAC study, and Field 2-6 is used to report results from the second pilot GAC study). The field titles, designations and cell ranges are summarized in Table 5-2, and the individual fields are described in Sections 5.1 through 5.7.

5.1 Field 1: PWS And Treatment Plant Data *(A3:B30)*

Exhibit 5-1 presents an example of Field 1 which is used to enter the Public Water System (PWS) and treatment plant data, including the PWSID#, plant ICR #, and addresses and phone numbers of the official and technical ICR contacts. Some of the information in Field 1 is optional (i.e., the WIDB number and e-mail addresses).

Field Title	Designation	Field Cell Range
PWS and Treatment Plant Data	1	A3:B30
Pilot-Scale GAC Design Parameters	2	D3:H35
Pretreatment Used Prior to GAC	3	J3:L24
Influent Water Quality For The 10- And 20-Minute, Pilot-Scale GAC Contactors	4	N3:BB55
Effluent Water Quality For The 10-Minute, Pilot-Scale GAC Contactor	5	BC3:CL55
Effluent Water Quality For The 20-Minute, Pilot-Scale GAC Contactor	6	CN3:DW55
GAC Cost Parameters	7	DY3:DZ20

Table 5-2 Summary Of Pilot-Scale GAC Data Fields

5.2 Field 2: Pilot-Scale GAC Design Parameters *(D3:H35)*

Exhibit 5-2 presents an example of Field 2 which uses information input by the user to calculate the design parameters for the pilot-scale GAC study. The following parameters must be entered in the first block of this field, ***Input Design Parameters (D4:E13)***, to calculate the pilot-scale design parameters:

- Carbon manufacturer, trade name and type.
- An estimate of the average influent TOC concentration to the pilot GAC column in **mg/L**.
- The inner diameter of the pilot-scale column (D) in **mm**.
- The manufacturer reported dry bed density for the pilot column (ρ) in **kg/m^3**.
- The upper and lower mesh size for the GAC particles used in the pilot column.
- The volumetric flow rate (Q) in **L/hr**.

In the next block, ***Estimated Run Length (D15:E17)***, the number of bed volumes to 50% TOC breakthrough (BV_{50}) is estimated from the influent TOC concentration. The number of bed volumes for the run (BV_T) is estimated as twice the number of bed volumes for 50% TOC breakthrough.

The next block, ***General Pilot Design Parameters (D19:E23)***, calculates the average carbon particle diameter (d), the column cross-sectional area (A) and the hydraulic loading rate or superficial velocity (v). The average carbon particle diameter is calculated from the mesh sizes entered in the first block and the ***US Standard Mesh Sizes (G4:H19)***. If the mesh sizes used for the pilot-scale GAC study do not appear in this table, it will be necessary to manually calculate the average particle size of the pilot-scale carbon and enter the value into cell ***E20***, overwriting the equation in this cell. To overwrite an equation in the spreadsheet, the sheet must be Unprotected and the cell unLocked as described in Section 3.3.

The last two blocks in this field, ***10-Minute EBCT Run (D25:E29)*** and ***20-Minute EBCT Run (D31:E35)***, calculate the specific design parameters for the 10- and 20-minute EBCT runs including an estimate of the pilot column run time (t), the required carbon bed length (l) and the dry mass of GAC required for the pilot column (m).

5.3 Field 3: Pretreatment Used Prior To GAC *(J3:L24)*

Exhibit 5-3 presents an example of Field 3 which is used to report all pretreatment processes used prior to the pilot-scale GAC column. All full-scale and pilot-scale pretreatment processes should be listed in this field. The process name should be entered, along with a brief description of the process (e.g., chemical dose, settler type, filter media, etc.) and the scale of the process (i.e., full-scale or pilot-scale). Detailed design information is not required in this spreadsheet since this design data will be included in the hard-copy *Treatment Study Summary Report* described in Section 10.0 of this document. The purpose of Field 3 is to associate the pretreatment processes used during the pilot-scale GAC study with the data entered in the spreadsheet.

5.4 Field 4: GAC Influent Water Quality For The 10- and 20-Minute, Pilot-Scale GAC Contactors *(N3:BB55)*

Exhibit 5-4 presents an example of Field 4 which is used to report the water quality of the influent to the 10- and 20-minute pilot-scale columns after the influent has undergone all pretreatment processes to be used in the study. The influent water quality parameters, designated as "Group A," include pH, turbidity, alkalinity, temperature, total hardness, calcium hardness, ammonia, bromide, total organic carbon (TOC), absorbance at ultra-violet 254 nm (UV_{254}), SDS-chlorine demand, SDS-TOX, SDS-THM4 and SDS-HAA6[1]. All "Group A" water quality parameters must be sampled fifteen (15) times during each pilot-scale study. Additionally, the "Group A" water quality analyses must be duplicated for three (3) influent samples, and the duplicate water quality samples are designated as "Group D."

In the first block ***(N4:BB36)***, the results from the fifteen water quality analyses are entered, and ten extra rows are provided so that additional results can be reported if measured. The second column of the first block of Field 4 is used to designate whether or not a sample was duplicated. The results of duplicate samples are not entered into the first block of Field 4; instead the results from the *primary* and *duplicate* analyses are entered in the second block of Field 4 ***(N38:BB55)***. This block calculates the average and relative percent difference for the primary and duplicate analyses. Then the average results from the primary and duplicate analyses must be entered in the appropriate rows of the first block of Field 4. For example, Exhibit 5-4 indicates that sample A3 was duplicated, so the results of the primary and duplicate analyses are entered into the second block of Field 4 where the average and relative percent difference are calculated. Then the average value (Avg-A3) for the primary (A3) and duplicate (D-A3) analyses is entered in the first block. Field 4 also calculates SUVA, SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

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[1]Only six HAA species are required, but the additional three HAA species (TBAA, CDBAA and DCBAA) should be reported if measured.

The date and time at which the pilot study was started must be entered in cells ***P8:Q8*** of Field 4. This starting date and time are used to calculate the operation time at which samples were collected throughout the pilot-scale study. The date and time at which each influent sample was collected must be entered in the third and fourth columns of Field 4, and **the influent samples should be collected at the same time that the effluent samples from the 20-minute EBCT contactor are collected**. The spreadsheet calculates the operation time (in decimal hours) when the sample was collected as the difference between the sample collection date/time and the start date/time. **Note: If the system was shut-down for a significant period of time (e.g., more than 12 hours), the spreadsheet will not calculate an accurate operation time.** If this is the case, the operation time must be manually calculated and entered into the spreadsheet, overwriting the automatic calculation. To overwrite an equation in the spreadsheet, the sheet must be Unprotected and the cell unLocked as described in Section 3.3. The number of bed volumes passed at the time of sampling is calculated by dividing the operation time by either the 10- or 20-minute EBCT.

5.5 Field 5: GAC Effluent Water Quality For The 10-Minute EBCT Run *(BC3:CL55)*

Exhibit 5-5 presents an example of Field 5 which is used to report the effluent water quality for the 10-minute EBCT pilot-scale column as a function of operation time. The effluent water quality parameters for the 10-minute EBCT column, designated as "Group B," include pH, turbidity, temperature, ammonia, TOC, UV_{254}, SDS-chlorine demand, SDS-TOX, SDS-THM4 and SDS-HAA6. All "Group B" water quality parameters must be sampled fifteen (15) times during each study. Additionally, the "Group B" water quality analyses must be duplicated for three (3) effluent samples, and the duplicate water quality samples are designated as "Group D."

In the first block ***(BC4:CL36)***, the results from the fifteen water quality analyses are entered, and ten extra rows are provided so that additional results can be reported if measured. The second column of the first block of Field 5 is used to designate whether or not a sample was duplicated. The results of duplicate samples are not entered into the first block of Field 5; instead the results from the *primary* and *duplicate* analyses are entered in the second block of Field 5 ***(BC38:CL55)***. This block calculates the average and relative percent difference for the primary and duplicate samples. Then the average results from the primary and duplicate analyses must be entered in the appropriate rows of the first block of Field 5. For example, Exhibit 5-5 indicates that sample B3 was duplicated, so the results of the primary and duplicate analyses are entered into the second block of Field 5 where the average and relative percent difference are calculated. The average value (Avg-B3) for the primary (B3) and duplicate (D-B3) analyses is entered in the first block. Field 5 also calculates SUVA, SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

The date and time at which the 10-minute pilot run was started must be entered in cells ***BE8:BF8*** of Field 5. This starting date and time are used to calculate the operation time at which samples were collected throughout the pilot-scale study. The date and time at which each effluent sample was collected must be entered in the third and fourth columns of Field 5. The spreadsheet calculates the operation time (in decimal hours) when the sample was collected as the difference between the sample collection date/time and the start date/time. **Note: If the system was shut-down for a significant period of time (e.g., more than 12 hours), the**

spreadsheet will not calculate an accurate operation time. If this is the case, the operation time must be manually calculated and entered into the spreadsheet, overwriting the automatic calculation. To overwrite an equation in the spreadsheet, the sheet must be Unprotected and the cell unLocked as described in Section 3.3. The number of bed volumes passed through the column is calculated by dividing the operation time by the 10-minute EBCT.

5.6 Field 6: GAC Effluent Water Quality For The 20-Minute EBCT Run *(CN3:DW55)*

Field 6 is identical to Field 5 except that it is used to report the effluent water quality for the 20-minute EBCT as a function of operation time (i.e., the "Group C" water quality parameters). The spreadsheet calculates the operation time (in decimal hours) when the sample was collected as the difference between the sample collection date/time and the start date/time. Field 6 also calculates the bed volumes passed at the time of sampling as well as SUVA, SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

5.7 Field 7: GAC Cost Parameters *(DY3:DZ20)*

Field 7 is used to report the utility-specific cost parameters that are used to generate cost estimates for the use of GAC technology, and an example of Field 7 is shown in Exhibit 5-6. Example cost parameters are listed in Exhibit 5-6, but it is important to report cost parameters specific to the utility and not default or example values.

	A	B
3	**Field E-1: PWS And Treatment Plant Data**	
4		
5	PWS Name	Anytown Public Works
6	Public Water System Identification Number	OH1234567
7	Water Industry Data Base Number (*optional*)	######
8		
9	Official ICR Contact Person	Mr. Any Body
10	Mailing Address	#### Street
11		City, State Zip code
12	Phone Number	(###) ###-####
13	FAX Number	(###) ###-####
14	E-Mail Address (*optional*)	last.first@wtp.com
15		
16	Technical ICR Contact Person	Ms. Some One
17	Mailing Address	#### Street
18		City, State Zip code
19	Phone Number	(###) ###-####
20	FAX Number	(###) ###-####
21	E-Mail Address (*optional*)	last.first@wtp.com
22		
23	Plant Name	East WTP
24	Treatment Plant Category	CONV
25	Process Train Name	Conventional train
26	ICR Treatment Plant Identification Number	###
27	PWSID Number of Plant (*if assigned*)	Not assigned
28	Historical Minimum Water Temperature (^{o}C)	4.0
29	Historical Average Water Temperature (^{o}C)	14.6
30	State Approved Plant Capacity (MGD)	100.0
31		
32	**Exhibit 5-1 Example Of Field 1 For The Pilot GAC Data Sheet**	

	D	E	F	G	H
3	**Field E-2: Pilot-Scale GAC Design Parameters**				
4	***Input Design Parameters***			***US Standard Mesh Sizes***	
5	Carbon manufacturer	Company Name		US standard	Opening
6	Carbon trade name	GAC-123		mesh size	(mm)
7	Carbon type	Bituminous coal based		4	4.750
8	Pilot GAC influent TOC (mg/L)	4.0		6	3.350
9	Inner diameter of the pilot GAC column, D (mm)	50.8		8	2.360
10	Manufacturer reported dry bed density, ρ (kg/m^3)	490.0		10	2.000
11	Pilot GAC mesh size, upper (US standard mesh)	12		12	1.680
12	Pilot GAC mesh size, lower (US standard mesh)	40		16	1.180
13	Flow rate, Q (L/hr)	20.0		20	0.850
14				30	0.600
15	***Estimated Run Length***			40	0.425
16	Bed volumes to 50% TOC breakthrough, BV_{50}	3579		50	0.300
17	Estimated run length, BV_T (= 2 x BV_{50})	7158		60	0.250
18				70	0.210
19	***General Pilot Design Parameters***			80	0.180
20	Carbon particle diameter, d (mm)	1.053			
21	Column cross-sectional area, A (m^2)	2.027E-03			
22	Hydraulic loading rate[1], v (m/hr)	9.87			
23	1: If **v** is not in the range from 5 to 15 m/hr (2 to 6 gpm/ft^2) then either **Q** or **D** must be adjusted.				
24					
25	***10-Minute EBCT Run***				
26	Empty bed contact time, EBCT (min)	10			
27	Estimated run time, t (days)	50			
28	Pilot column bed length, l (m)	1.64			
29	Mass GAC required, m (kg)	1.633			
30					
31	***20-Minute EBCT Run***				
32	Empty bed contact time, EBCT (min)	20			
33	Estimated run time, t (days)	99			
34	Pilot column bed length, l (m)	3.29			
35	Mass GAC required, m (kg)	3.267			
36					
37	**Exhibit 5-2 Example Of Field 2 For Pilot GAC Data Sheet**				

	J	K	L
3	**Field E-3: Pretreatment Used Prior To GAC[1]**		
4			
5	**Process**	**Description**	**Scale**
6	Coagulation	50 $\pm$ 15 mg/L alum	Full-scale
7	Flocculation	2-stage	Full-scale
8	Sedimentation	tube settler	Full-scale
9	Dual media filtration	sand / anthracite	Pilot-scale
10	Sulfuric acid addition	pH = 6.0	Pilot-scale
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22	1: Design information, similar to that shown in Tables 6c and 6d of the ICR rule, must be included in		
23	the hard-copy *Treatment Study Summary Report* (see Section 10.0). The purpose of this table		
24	is to list the pretreatment processes used in this particular pilot GAC run.		
25			
26	**Exhibit 5-3 Example Of Field 3 For The Pilot GAC Data Sheet**		

	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB

3 **Field E-4: Influent Water Quality For The 10- And 20-Minute, Pilot-Scale GAC Contactors[1]**

4 ***Group A, 15 influent samples per run***

	Sample	Was sample	Sampling	Sampling	Operation	Bed	Bed	pH	Turbidity	Alkalinity	Temp.	Total	Calcium	Ammonia	Bromide
6	ID	duplicated?	date	time	time	volumes	volumes					Hardness	Hardness		
7		Y/N	MM/DD/YY	hh:mm	hh.hh	(20 minute)	(10 minute)	---	ntu	mg/L as $CaCO_3$	^oC	mg/L as $CaCO_3$	mg/L as $CaCO_3$	mg NH_3-N / L	µg/L
8	**START**	---	4/10/96	11:30	0.00	0.0	0.0	---	---	---	---	---	---	---	---
9	**A1**	N	4/11/96	11:30	24.00	72.0	144.0	6.00	1.00	74.0	17.0	310.0	275.0	40.0	98.0
10	**A2**	N	4/16/96	23:30	156.00	468.0	936.0	5.90	1.10	74.0	18.0	300.0	270.0	41.0	94.0
11	**Avg-A3**	Y	4/22/96	11:30	288.00	864.0	1728.0	6.00	1.00	79.0	18.0	288.0	264.0	41.0	96.0
12	**A4**	N	4/27/96	11:30	408.00	1224.0	2448.0	6.00	0.90	88.0	19.0	302.0	271.0	38.0	96.0
13	**A5**	N	5/3/96	11:30	552.00	1656.0	3312.0	6.10	0.80	76.0	19.0	305.0	272.0	39.0	92.0
14	**A6**	N	5/8/96	11:30	672.00	2016.0	4032.0	5.80	0.80	74.0	19.0	310.0	275.0	37.0	90.0
15	**Avg-A7**	Y	5/14/96	11:30	816.00	2448.0	4896.0	5.80	0.80	75.0	20.0	315.0	280.0	38.0	89.0
16	**A8**	N	5/19/96	11:30	936.00	2808.0	5616.0	5.90	0.90	75.0	20.0	315.0	280.0	35.0	91.0
17	**A9**	N	5/25/96	11:30	1080.00	3240.0	6480.0	6.10	1.00	79.0	20.0	300.0	270.0	36.0	93.0
18	**A10**	N	5/30/96	11:30	1200.00	3600.0	7200.0	6.10	1.00	81.0	21.0	296.0	268.0	41.0	88.0
19	**Avg-A11**	Y	6/8/96	11:30	1416.00	4248.0	8496.0	6.20	1.10	80.0	21.0	288.0	265.0	42.0	91.0
20	**A12**	N	6/16/96	11:30	1608.00	4824.0	9648.0	6.00	0.80	80.0	21.0	284.0	261.0	42.0	92.0
21	**A13**	N	6/24/96	11:30	1800.00	5400.0	10800.0	6.20	0.90	82.0	21.0	289.0	265.0	40.0	88.0
22	**A14**	N	7/2/96	11:30	1992.00	5976.0	11952.0	6.00	0.95	76.0	20.5	289.0	265.0	41.0	87.0
23	**A15**	N	7/15/96	11:30	2304.00	6912.0	13824.0	6.00	1.10	78.0	20.5	300.0	270.0	39.0	86.0
24					-843971.50	-2531914.5	-5063829.0								
25					-843971.50	-2531914.5	-5063829.0								
26					-843971.50	-2531914.5	-5063829.0								
27					-843971.50	-2531914.5	-5063829.0								
28					-843971.50	-2531914.5	-5063829.0								
29					-843971.50	-2531914.5	-5063829.0								
30					-843971.50	-2531914.5	-5063829.0								
31					-843971.50	-2531914.5	-5063829.0								
32					-843971.50	-2531914.5	-5063829.0								
33					-843971.50	-2531914.5	-5063829.0								

34 BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

35 *: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

36 1: Do not enter the results from duplicate samples into the table above, instead enter the average value for the primary and duplicate analyses in the above table, and enter the results for the primary and duplicate analyses below.

37

38 ***Group D, 3 duplicate influent samples per run***

	Sample	Sample	Sampling	Sampling	Operation	Bed	Bed	pH	Turbidity	Alkalinity	Temp.	Total	Calcium	Ammonia	Bromide
40	ID	Type	date	time	time	volumes	volumes					Hardness	Hardness		
41			MM/DD/YY	hh:mm	hh.hh	(20 minute)	(10 minute)	---	ntu	mg/L as $CaCO_3$	^oC	mg/L as $CaCO_3$	mg/L as $CaCO_3$	mg NH_3-N / L	µg/L
42	**A3**	Primary	4/22/96	11:30	288.00	864.0	1728.0	5.90	0.90	80.0	18.0	292.0	260.0	42.0	95.0
43	**D-A3**	Duplicate	4/22/96	11:30	288.00	864.0	1728.0	6.10	1.10	78.0	18.0	284.0	268.0	40.0	97.0
44	**Avg-A3**	Average	---	---	---	---	---	6.00	1.00	79.0	18.0	288.0	264.0	41.0	96.0
45	**RPD-A3**	RPD	---	---	---	---	---	3.33	20.00	2.53	0.00	2.78	3.03	4.88	2.08
46	**A7**	Primary	5/14/96	11:30	816.00	2448.0	4896.0	5.70	0.75	70.0	20.0	310.0	285.0	39.0	88.0
47	**D-A7**	Duplicate	5/14/96	11:30	816.00	2448.0	4896.0	5.90	0.85	80.0	20.0	320.0	275.0	37.0	90.0
48	**Avg-A7**	Average	---	---	---	---	---	5.80	0.80	75.0	20.0	315.0	280.0	38.0	89.0
49	**RPD-A7**	RPD	---	---	---	---	---	3.45	12.50	13.33	0.00	3.17	3.57	5.26	2.25
50	**A11**	Primary	6/8/96	11:30	1416.00	4248.0	8496.0	6.20	1.00	78.0	21.0	286.0	260.0	44.0	90.0
51	**D-A11**	Duplicate	6/8/96	11:30	1416.00	4248.0	8496.0	6.20	1.20	82.0	21.0	290.0	270.0	44.0	92.0
52	**Avg-A11**	Average	---	---	---	---	---	6.20	1.10	80.0	21.0	288.0	265.0	44.0	91.0
53	**RPD-A11**	RPD	---	---	---	---	---	0.00	18.18	5.00	0.00	1.39	3.77	0.00	2.20

54 BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

55 *: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

56

57 **Exhibit 5-4 Example Of Field 4 For The Pilot GAC Data Sheet (page 1 of 3)**

	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
3	**Field E-4: Influent Water Quality For The 10- And 20-Minute, Pilot-Scale GAC Contactors (continued)**															
4																
5	**TOC**	**UV_{254}**	**SUVA**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**
6				**Cl_2 dose**	**Free Cl_2 residual**	**Cl_2 demand**	**Chlorination temp.**	**Chlorination pH**	**Incubation time**	**TOX**	***CHCl3***	***BDCM***	***DBCM***	***CHBr3***	**THM4**	***MCAA****
7	mg/L	cm^{-1}	L/(mg*m)	mg/L	mg/L	mg/L	^{o}C	---	hours	µg Cl^-/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
9	4.65	0.189	4.06	5.52	0.95	4.57	19.8	7.54	84.0	428.00	71.00	18.00	6.80	BMRL	95.80	2.80
10	4.72	0.175	3.71	6.03	1.03	5.00	19.9	7.83	82.5	414.00	63.00	21.00	7.10	0.57	91.67	2.45
11	4.68	0.179	3.82	5.86	1.05	4.81	20.2	7.65	83.6	436.00	76.00	19.00	7.20	0.42	102.62	2.68
12	4.91	0.192	3.91	5.94	1.05	4.89	20.2	8.03	84.2	428.00	75.00	19.00	6.50	BMRL	100.50	3.04
13	4.98	0.195	3.92	6.20	1.00	5.20	20.3	7.86	84.0	421.00	72.00	16.00	7.60	BMRL	95.60	2.87
14	4.79	0.169	3.53	6.18	0.94	5.24	20.5	7.94	84.7	411.00	68.00	20.00	7.40	0.54	95.94	2.94
15	4.63	0.176	3.80	6.25	1.02	5.23	20.7	8.02	85.3	409.00	64.00	22.00	7.10	0.63	93.73	2.68
16	4.82	0.186	3.86	6.30	0.90	5.40	21.0	7.56	85.1	422.00	66.00	19.00	7.50	BMRL	92.50	2.34
17	4.91	0.192	3.91	6.40	0.94	5.46	21.3	8.06	84.6	418.00	68.00	17.00	6.90	0.48	92.38	2.69
18	4.88	0.184	3.77	6.55	1.10	5.45	21.2	8.02	83.6	415.00	63.00	19.00	6.80	0.42	89.22	3.05
19	4.85	0.180	3.71	6.08	1.09	4.99	21.5	8.04	83.4	407.00	64.00	21.00	6.90	0.55	92.45	2.78
20	4.90	0.201	4.10	6.15	1.06	5.09	21.7	8.00	84.6	424.00	71.00	20.00	7.10	0.63	98.73	2.68
21	4.67	0.194	4.15	5.52	1.00	4.52	21.8	7.94	84.9	435.00	77.00	20.00	7.00	0.42	104.42	2.94
22	4.73	0.188	3.97	5.52	1.00	4.52	21.8	7.86	85.0	431.00	77.00	19.00	6.60	BMRL	102.60	2.78
23	4.61	0.169	3.67	5.52	1.05	4.47	21.9	7.75	84.5	427.00	73.00	17.00	6.70	0.48	97.18	2.90
24			#DIV/0!			0.00									0.00	
25			#DIV/0!			0.00									0.00	
26			#DIV/0!			0.00									0.00	
27			#DIV/0!			0.00									0.00	
28			#DIV/0!			0.00									0.00	
29			#DIV/0!			0.00									0.00	
30			#DIV/0!			0.00									0.00	
31			#DIV/0!			0.00									0.00	
32			#DIV/0!			0.00									0.00	
33			#DIV/0!			0.00									0.00	
34	BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported															
35	*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.															
36																
37																
38																
39	**TOC**	**UV_{254}**	**SUVA**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**
40				**Cl_2 dose**	**Free Cl_2 residual**	**Cl_2 demand**	**Chlorination temp.**	**Chlorination pH**	**Incubation time**	**TOX**	***CHCl3***	***BDCM***	***DBCM***	***CHBr3***	**THM4**	***MCAA****
41	mg/L	cm^{-1}	L/(mg*m)	mg/L	mg/L	mg/L	^{o}C	---	hours	µg Cl^-/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
42	4.72	0.185	3.92	5.82	1.00	4.82	20.2	7.70	83.6	440.00	80.00	19.00	7.60	0.40	107.00	2.74
43	4.64	0.173	3.73	5.90	1.10	4.80	20.2	7.60	83.6	432.00	72.00	19.00	6.80	0.44	98.24	2.62
44	4.68	0.179	3.82	5.86	1.05	4.81	20.2	7.65	83.6	436.00	76.00	19.00	7.20	0.42	102.62	2.68
45	1.71	6.70	5.00	1.37	9.52	0.42	0.00	1.31	0.00	1.83	10.53	0.00	11.11	9.52	8.54	4.48
46	4.66	0.178	3.82	6.20	1.02	5.18	20.7	8.04	85.4	412.00	65.00	24.00	6.90	0.63	96.53	2.59
47	4.60	0.174	3.78	6.30	1.02	5.28	20.8	8.00	85.2	406.00	63.00	20.00	7.30	0.63	90.93	2.76
48	4.63	0.176	3.80	6.25	1.02	5.23	20.7	8.02	85.3	409.00	64.00	22.00	7.10	0.63	93.73	2.68
49	1.30	2.27	0.98	1.60	0.00	1.91	0.48	0.50	0.23	1.47	3.13	18.18	5.63	0.00	5.97	6.36
50	4.90	0.180	3.67	6.10	1.08	5.02	21.4	8.06	83.2	424.00	68.00	23.00	6.90	0.60	98.50	2.94
51	4.80	0.180	3.75	6.06	1.10	4.96	21.6	8.02	83.6	390.00	60.00	19.00	6.90	0.50	86.40	2.62
52	4.85	0.180	3.71	6.08	1.09	4.99	21.5	8.04	83.4	407.00	64.00	21.00	6.90	0.55	92.45	2.78
53	2.06	0.00	2.06	0.66	1.83	1.20	0.93	0.50	0.48	8.35	12.50	19.05	0.00	18.18	13.09	11.51
54	BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported															
55	*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.															
56																
57	**Exhibit 5-4 Example Of Field 4 For The Pilot GAC Data Sheet (page 2 of 3)**															

Field E-4: Influent Water Quality For The 10- And 20-Minute, Pilot-Scale GAC Contactors (continued)

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB
5	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**
6	***DCAA****	***TCAA****	***MBAA****	***DBAA****	***BCAA****	***TBAA***	***CDBAA***	***DCBAA***	**HAA5**	**HAA6**
7	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
8	---	---	---	---	---	---	---	---	---	---
9	17.60	38.70	1.02	2.29	16.70	NA	NA	NA	62.41	79.11
10	18.92	38.10	0.78	2.51	17.30	NA	NA	NA	62.76	80.06
11	18.64	37.75	0.69	2.04	16.85	NA	NA	NA	61.80	78.65
12	16.25	38.26	0.64	2.78	16.44	NA	NA	NA	60.97	77.41
13	17.89	36.94	0.88	2.49	17.20	NA	NA	NA	61.07	78.27
14	17.46	37.65	0.91	2.44	16.84	NA	NA	NA	61.40	78.24
15	17.60	37.89	0.65	2.65	16.75	NA	NA	NA	61.47	78.22
16	16.90	36.90	0.79	2.15	16.70	NA	NA	NA	59.08	75.78
17	16.80	36.65	1.03	2.09	17.21	NA	NA	NA	59.26	76.47
18	17.48	37.45	0.95	2.66	17.33	NA	NA	NA	61.59	78.92
19	17.62	38.40	0.75	2.82	16.94	NA	NA	NA	62.37	79.31
20	17.96	36.91	0.88	1.95	16.84	NA	NA	NA	60.38	77.22
21	16.80	37.22	0.71	2.47	17.14	NA	NA	NA	60.14	77.28
22	17.60	38.90	0.66	2.94	17.20	NA	NA	NA	62.88	80.08
23	17.56	38.45	0.81	2.74	17.18	NA	NA	NA	62.46	79.64
24									0.00	0.00
25									0.00	0.00
26									0.00	0.00
27									0.00	0.00
28									0.00	0.00
29									0.00	0.00
30									0.00	0.00
31									0.00	0.00
32									0.00	0.00
33									0.00	0.00

BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB
39	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**
40	***DCAA****	***TCAA****	***MBAA****	***DBAA****	***BCAA****	***TBAA***	***CDBAA***	***DCBAA***	**HAA5**	**HAA6**
41	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
42	19.00	39.00	0.69	2.06	17.00	NA	NA	NA	63.49	80.49
43	18.28	36.50	0.69	2.02	16.70	NA	NA	NA	60.11	76.81
44	18.64	37.75	0.69	2.04	16.85	#DIV/0!	#DIV/0!	#DIV/0!	61.80	78.65
45	3.86	6.62	0.00	1.96	1.78	#VALUE!	#VALUE!	#VALUE!	5.47	4.68
46	17.80	38.00	0.70	2.75	16.80	NA	NA	NA	61.84	78.64
47	17.40	37.78	0.60	2.54	16.70	NA	NA	NA	61.08	77.78
48	17.60	37.89	0.65	2.65	16.75	#DIV/0!	#DIV/0!	#DIV/0!	61.46	78.21
49	2.27	0.58	15.38	7.94	0.60	#VALUE!	#VALUE!	#VALUE!	1.24	1.10
50	17.44	39.00	0.80	2.86	16.85	NA	NA	NA	63.04	79.89
51	17.80	37.80	0.70	2.78	17.02	NA	NA	NA	61.70	78.72
52	17.62	38.40	0.75	2.82	16.94	#DIV/0!	#DIV/0!	#DIV/0!	62.37	79.31
53	2.04	3.13	13.33	2.84	1.00	#VALUE!	#VALUE!	#VALUE!	2.15	1.48

BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT

3 **Field E-5: Effluent Water Quality For The 10-Minute, Pilot-Scale GAC Contactor[1]**

4 ***Group B, 15 effluent samples per run***

	Sample ID	Was sample duplicated?	Sampling date	Sampling time	Operation time	Bed volumes	pH	Turbidity	Temp.	Ammonia	TOC	UV_{254}	SUVA	SDS Cl_2 dose	SDS Free Cl_2 residual	SDS Cl_2 demand	SDS Chlorination temp.
7		Y/N	MM/DD/YY	hh:mm	hh.hh	(10 minute)	---	ntu	°C	mg NH_3-N / L	mg/L	cm^{-1}	L/(mg*m)	mg/L	mg/L	mg/L	°C
8	**START**	---	4/10/96	11:30	0.00	0.0	---	---	---	---	---	---	---	---	---	---	---
9	**B1**	N	4/11/96	11:30	24.00	144.0	6.00	0.90	17.0	20.0	0.21	0.005	2.38	1.32	0.95	0.37	19.8
10	**B2**	N	4/14/96	4:20	88.83	533.0	5.90	1.00	18.0	21.0	0.46	0.011	2.39	1.50	1.03	0.47	19.9
11	**Avg-B3**	Y	4/16/96	21:10	153.67	922.0	6.00	0.90	18.0	21.0	0.76	0.017	2.24	1.75	1.05	0.70	20.2
12	**B4**	N	4/19/96	14:00	218.50	1311.0	6.00	0.80	19.0	18.0	0.95	0.024	2.53	2.01	1.05	0.96	20.2
13	**B5**	N	4/22/96	11:30	288.00	1728.0	6.10	0.70	19.0	19.0	1.20	0.032	2.67	2.23	1.00	1.23	20.3
14	**B6**	N	4/24/96	11:30	336.00	2016.0	5.80	0.70	19.0	17.0	1.44	0.038	2.64	2.50	0.94	1.56	20.5
15	**Avg-B7**	Y	4/27/96	11:30	408.00	2448.0	5.80	0.70	20.0	18.0	1.66	0.044	2.65	2.67	1.02	1.65	20.7
16	**B8**	N	4/30/96	11:30	480.00	2880.0	5.90	0.80	20.0	15.0	1.92	0.054	2.81	2.94	0.90	2.04	21.0
17	**B9**	N	5/3/96	11:30	552.00	3312.0	6.10	0.90	20.0	16.0	2.12	0.069	3.25	3.23	0.94	2.29	21.3
18	**B10**	N	5/5/96	11:30	600.00	3600.0	6.10	0.90	21.0	21.0	2.40	0.080	3.33	3.41	1.10	2.31	21.2
19	**Avg-B11**	Y	5/9/96	11:30	696.00	4176.0	6.20	1.00	21.0	22.0	2.60	0.094	3.62	3.72	1.09	2.63	21.5
20	**B12**	N	5/13/96	11:30	792.00	4752.0	6.00	0.70	21.0	22.0	2.90	0.105	3.62	3.90	1.06	2.84	21.7
21	**B13**	N	5/17/96	11:30	888.00	5328.0	6.20	0.80	21.0	20.0	3.12	0.109	3.49	4.15	1.00	3.15	21.8
22	**B14**	N	5/21/96	11:30	984.00	5904.0	6.00	0.85	20.5	21.0	3.31	0.124	3.75	4.45	1.00	3.45	21.8
23	**B15**	N	5/26/96	11:30	1104.00	6624.0	6.00	1.00	20.5	19.0	3.54	0.136	3.84	4.75	1.05	3.70	21.9
24					-843971.50	-5063829.0							#DIV/0!			0.00	
25					-843971.50	-5063829.0							#DIV/0!			0.00	
26					-843971.50	-5063829.0							#DIV/0!			0.00	
27					-843971.50	-5063829.0							#DIV/0!			0.00	
28					-843971.50	-5063829.0							#DIV/0!			0.00	
29					-843971.50	-5063829.0							#DIV/0!			0.00	
30					-843971.50	-5063829.0							#DIV/0!			0.00	
31					-843971.50	-5063829.0							#DIV/0!			0.00	
32					-843971.50	-5063829.0							#DIV/0!			0.00	
33					-843971.50	-5063829.0							#DIV/0!			0.00	

34 BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

35 *: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

36 1: Do not enter the results from duplicate samples into the table above, instead enter the average value for the primary and duplicate analyses in the above table, and enter the results for the primary and duplicate analyses below.

37

38 ***Group D, 3 duplicate effluent samples per run***

	Sample ID	Sample Type	Sampling date	Sampling time	Operation time	Bed volumes	pH	Turbidity	Temp.	Ammonia	TOC	UV_{254}	SUVA	SDS Cl_2 dose	SDS Free Cl_2 residual	SDS Cl_2 demand	SDS Chlorination temp.
41			MM/DD/YY	hh:mm	hh.hh	(10 minute)	---	ntu	°C	mg NH_3-N / L	mg/L	cm^{-1}	L/(mg*m)	mg/L	mg/L	mg/L	°C
42	**B3**	Primary	4/16/96	21:10	153.67	922.0	5.90	0.80	18.0	22.0	0.72	0.015	2.10	1.80	1.00	0.80	20.3
43	**D-B3**	Duplicate	4/16/96	21:10	153.67	922.0	6.10	1.00	18.0	20.0	0.80	0.019	2.38	1.70	1.10	0.60	20.1
44	**Avg-B3**	Average	---	---	---	---	6.00	0.90	18.0	21.0	0.76	0.017	2.24	1.75	1.05	0.70	20.2
45	**RPD-B3**	RPD	---	---	---	---	3.33	22.22	0.00	9.52	10.53	22.87	12.42	5.71	9.52	28.57	0.99
46	**B7**	Primary	4/27/96	11:30	408.00	2448.0	5.80	0.75	20.0	19.0	1.74	0.042	2.41	2.70	1.05	1.65	20.6
47	**D-B7**	Duplicate	4/27/96	11:30	408.00	2448.0	5.80	0.65	20.0	17.0	1.58	0.046	2.91	2.63	0.99	1.64	20.8
48	**Avg-B7**	Average	---	---	---	---	5.80	0.70	20.0	18.0	1.66	0.044	2.66	2.67	1.02	1.65	20.7
49	**RPD-B7**	RPD	---	---	---	---	0.00	14.29	0.00	11.11	9.64	9.09	18.69	2.63	5.88	0.61	0.97
50	**B11**	Primary	5/9/96	11:30	696.00	4176.0	6.20	1.10	21.0	20.0	2.70	0.090	3.33	3.76	1.05	2.71	21.7
51	**D-B11**	Duplicate	5/9/96	11:30	696.00	4176.0	6.20	0.90	21.0	24.0	2.50	0.098	3.92	3.68	1.13	2.55	21.3
52	**Avg-B11**	Average	---	---	---	---	6.20	1.00	21.0	22.0	2.60	0.094	3.63	3.72	1.09	2.63	21.5
53	**RPD-B11**	RPD	---	---	---	---	0.00	20.00	0.00	18.18	7.69	8.51	16.18	2.15	7.34	6.08	1.86

54 BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

55 *: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

56

57 **Exhibit 5-5 Example Of Field 5 For The Pilot GAC Data Sheet (page 1 of 2)**

	BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM
3	**Field E-5: Effluent Water Quality For The 10-Minute, Pilot-Scale GAC Contactor (continued)**																		
4																			
5	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**
6	**Chlorination pH**	**Incubation time**	**TOX**	***CHCl3***	***BDCM***	***DBCM***	***CHBr3***	**THM4**	***MCAA****	***DCAA****	***TCAA****	***MBAA****	***DBAA****	***BCAA****	***TBAA***	***CDBAA***	***DCBAA***	**HAA5**	**HAA6**
7	---	hours	µg Cl⁻/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
9	7.54	84.0	32.00	2.45	BMRL	BMRL	2.79	5.24	BMRL	BMRL	3.76	2.31	1.77	2.11	NA	NA	NA	7.84	9.95
10	7.83	82.5	55.00	4.15	0.94	BMRL	2.56	7.65	BMRL	BMRL	6.24	2.14	2.03	2.84	NA	NA	NA	10.41	13.25
11	7.65	83.6	82.00	6.55	1.78	0.71	2.04	11.08	BMRL	0.78	7.69	1.86	2.33	3.44	NA	NA	NA	12.66	16.10
12	8.03	84.2	97.00	8.77	3.21	1.19	1.79	14.96	BMRL	1.32	8.80	1.54	3.15	4.02	NA	NA	NA	14.81	18.83
13	7.86	84.0	126.00	11.10	4.61	2.11	1.60	19.42	0.52	2.11	10.30	1.03	2.74	3.11	NA	NA	NA	16.70	19.81
14	7.94	84.7	146.00	15.63	5.47	3.16	1.46	25.72	BMRL	2.56	11.20	0.95	2.64	2.87	NA	NA	NA	17.35	20.22
15	8.02	85.3	163.00	19.20	6.24	3.54	1.31	30.29	BMRL	3.14	13.40	0.84	2.21	3.78	NA	NA	NA	19.59	23.37
16	7.56	85.1	186.00	24.60	7.30	4.06	1.17	37.13	0.67	4.46	14.50	0.79	1.77	4.77	NA	NA	NA	22.19	26.96
17	8.06	84.6	214.00	28.16	8.40	4.35	0.94	41.85	0.84	4.99	16.80	0.73	1.64	6.08	NA	NA	NA	25.00	31.08
18	8.02	83.6	233.00	33.70	9.30	4.60	0.81	48.41	1.23	5.98	17.90	0.76	1.22	7.61	NA	NA	NA	27.09	34.70
19	8.04	83.4	249.00	39.40	11.00	4.76	0.69	55.85	1.58	6.77	19.20	0.60	1.15	8.92	NA	NA	NA	29.30	38.22
20	8.00	84.6	275.00	42.60	11.70	4.91	0.54	59.75	1.69	7.79	21.40	0.66	1.53	9.91	NA	NA	NA	33.07	42.98
21	7.94	84.9	286.00	47.30	12.60	5.21	0.42	65.53	2.03	8.26	23.60	0.59	1.69	10.22	NA	NA	NA	36.17	46.39
22	7.86	85.0	319.00	49.80	13.70	5.30	0.65	69.45	2.08	9.18	25.70	0.68	1.84	11.30	NA	NA	NA	39.48	50.78
23	7.75	84.5	333.00	54.00	14.80	5.61	0.79	75.20	2.21	10.30	28.30	0.67	2.03	12.00	NA	NA	NA	43.51	55.51
24								0.00										0.00	0.00
25								0.00										0.00	0.00
26								0.00										0.00	0.00
27								0.00										0.00	0.00
28								0.00										0.00	0.00
29								0.00										0.00	0.00
30								0.00										0.00	0.00
31								0.00										0.00	0.00
32								0.00										0.00	0.00
33								0.00										0.00	0.00
34	BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported																		
35	*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.																		
36																			
37																			
38																			
39	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**	**SDS**
40	**Chlorination pH**	**Incubation time**	**TOX**	***CHCl3***	***BDCM***	***DBCM***	***CHBr3***	**THM4**	***MCAA****	***DCAA****	***TCAA****	***MBAA****	***DBAA****	***BCAA****	***TBAA***	***CDBAA***	***DCBAA***	**HAA5**	**HAA6**
41	---	hours	µg Cl⁻/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
42	7.65	83.6	79.00	6.40	1.84	0.70	2.00	10.94	BMRL	0.82	7.78	1.90	2.36	3.55	NA	NA	NA	12.86	16.41
43	7.65	83.6	85.00	6.70	1.72	0.72	2.08	11.22	BMRL	0.74	7.60	1.82	2.30	3.32	NA	NA	NA	12.46	15.78
44	7.65	83.6	82.00	6.55	1.78	0.71	2.04	11.08	#DIV/0!	0.78	7.69	1.86	2.33	3.44	#DIV/0!	#DIV/0!	#DIV/0!	12.66	16.10
45	0.00	0.00	7.32	4.58	6.74	2.82	3.92	2.53	#VALUE!	10.26	2.34	4.30	2.58	6.70	#VALUE!	#VALUE!	#VALUE!	3.16	3.91
46	8.05	85.2	160.00	19.10	6.10	3.42	1.36	29.98	BMRL	3.20	13.60	0.90	2.34	3.71	NA	NA	NA	20.04	23.75
47	7.98	85.4	166.00	19.30	6.38	3.66	1.25	30.59	BMRL	3.08	13.20	0.78	2.08	3.85	NA	NA	NA	19.14	22.99
48	8.02	85.3	163.00	19.20	6.24	3.54	1.31	30.29	#DIV/0!	3.14	13.40	0.84	2.21	3.78	#DIV/0!	#DIV/0!	#DIV/0!	19.59	23.37
49	0.87	0.23	3.68	1.04	4.49	6.78	8.43	2.01	#VALUE!	3.82	2.99	14.29	11.76	3.70	#VALUE!	#VALUE!	#VALUE!	4.59	3.25
50	8.05	83.5	245.00	40.00	11.50	4.84	0.77	57.11	1.60	6.80	19.30	0.55	1.10	9.00	NA	NA	NA	29.35	38.35
51	8.03	83.3	253.00	38.80	10.50	4.68	0.60	54.58	1.56	6.73	19.10	0.65	1.20	8.84	NA	NA	NA	29.24	38.08
52	8.04	83.4	249.00	39.40	11.00	4.76	0.69	55.85	1.58	6.77	19.20	0.60	1.15	8.92	#DIV/0!	#DIV/0!	#DIV/0!	29.30	38.22
53	0.25	0.24	3.21	3.05	9.09	3.36	24.82	4.53	2.53	1.03	1.04	16.67	8.70	1.79	#VALUE!	#VALUE!	#VALUE!	0.38	0.71
54	BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported																		
55	*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.																		
56																			
57	**Exhibit 5-5 Example Of Field 5 For The Pilot GAC Data Sheet (page 2 of 2)**																		

	DZ	EA
3	**Field E-7: GAC Cost Parameters**	
4		
5	**Cost Parameter**	**Parameter value**
6	Capital Recovery Interest Rate (%)	10
7	Capital Recovery Period (years)	20
8	Overhead & Profit Factor (% of construction costs)	5
9	Special Sitework Factor (% of construction costs)	5
10	Construction Contingencies (% of construction costs)	10
11	Engineering Fee Factor (% of construction costs)	10
12	1998 ENR Construction Cost Index (CCI base year 1913)	####
13	1998 Producers Price Index (PPI base year 1967 = 100)	###
14	Labor Rate + Fringe ($/work-hour)	15
15	Labor Overhead Factor (% of labor)	10
16	Electric Rate ($/kW-h)	0.086
17	Fuel Oil Rate ($/gal)	0.89
18	Natural Gas Rate ($/ft^3)	0.0055
19	Current Process Water Rate ($/1000 gal)	0.35
20	Modifications to Existing Plant (% of construction costs)	5
21		
22	**Exhibit 5-6 Example Of Field 7 For The Pilot GAC Data Sheet**	

Appendix 5a: GAC Pilot-Scale Equations And Nomenclature

<u>**Nomenclature**</u>

A	Cross-sectional area of pilot column **(m^2)**
BCAA	Bromochloroacetic acid **(μg/L)**
BDCAA	Bromodichloroacetic acid **(μg/L)**
BDCM	Bromodichloromethane **(μg/L)**
BMRL	Below minimum reporting level
BV	Number of bed volumes passed
BV_{50}	Estimated number of bed volumes to 50% TOC breakthrough
BV_T	Estimated total number of bed volumes over the run
CHBr3	Bromoform **(μg/L)**
CHCl3	Chloroform **(μg/L)**
d	Carbon particle diameter used in pilot-scale columns **(mm)**
D	Inner diameter of the pilot-scale column **(mm)**
DBAA	Dibromoacetic acid **(μg/L)**
DBCAA	Dibromochloroacetic acid **(μg/L)**
DBCM	Dibromochloromethane **(μg/L)**
DCAA	Dichloroacetic acid **(μg/L)**
EBCT	Pilot column empty bed contact time **(min)**
l	Pilot column carbon bed length **(m)**
m	Mass of carbon required for pilot column **(kg)**
MBAA	Monobromoacetic acid **(μg/L)**
MCAA	Monochloroacetic acid **(μg/L)**
NA	Not analyzed
NR	Not reported
Q	Volumetric flow rate for the pilot-scale column **(L/hr)**
SDS	Simulated distribution system
SDS-CD	SDS chlorine demand **(mg/L)**
SDS-Cl Dose	SDS chlorine dose **(mg/L)**
SDS-CR	SDS free chlorine residual **(mg/L)**
SDS-HAA5	The sum of five haloacetic acids evaluated under SDS conditions **(μg/L)**
SDS-HAA6	The sum of six haloacetic acids evaluated under SDS conditions **(μg/L)**
SDS-THM4	The sum of four trihalomethanes evaluated under SDS conditions **(μg/L)**
SDS-TOX	Total organic halides evaluated under SDS conditions **(μg CL^-/L)**
SUVA	Specific ultraviolet absorbance **(L/(mg*m))**
t	Estimated pilot-scale run time **(days)**
TBAA	Tribromoacetic acid **(μg/L)**
TCAA	Trichloroacetic acid **(μg/L)**
TOC	Total organic carbon **(mg/L)**
TOC_I	Influent TOC **(mg/L)**
UV_{254}	Ultra-violet absorbance at 254 nm **(cm^{-1})**
v	Superficial velocity or hydraulic loading rate **(m/hr)**
ρ	Manufacturer reported dry bed density **(kg/cm)**

PILOT GAC DESIGN CALCULATIONS

Bed Volumes To 50% TOC Breakthrough (Example cell: E16)

$$\mathbf{BV_{50} = 21{,}700 \times TOC_I^{-1.3}} \qquad \textbf{(5a.1)}$$

Estimated Run Length In Bed Volumes (Example cell: E17)

$$\mathbf{BV_T = 2 \times BV_{50}} \qquad \textbf{(5a.2)}$$

Pilot Carbon Particle Diameter (Example cell: E20)

d = (Pilot GAC upper mesh diameter + Pilot GAC lower mesh diameter) / 2 **(5a.3)**

Note: The upper and lower mesh diameters are determined from the Standard US Mesh Sizes listed in cell block G4:H19.

Column Cross-Section Area (Example cell: E21)

$$\mathbf{A = (\pi / 4) \times (D \times 0.001)^2} \qquad \textbf{(5a.4)}$$

Hydraulic Loading Rate For Pilot-Scale Column (Example cell: E22)

$$\mathbf{v = (Q / 1000) / A} \qquad \textbf{(5a.5)}$$

Estimated Pilot-Scale Run Time (Example cells: E27, E33)

$$\mathbf{t = (BV_T \times EBCT) / (60 \times 24)} \qquad \textbf{(5a.6)}$$

Pilot Column GAC Bed Length (Example cells: E28, E34)

$$\mathbf{l = v \times EBCT / 60} \qquad \textbf{(5a.7)}$$

Mass Of GAC Required For Pilot Column (Example cells: E29, E35)

$$\mathbf{m = \rho \times l \times A} \qquad \textbf{(5a.8)}$$

Bed Volumes (Example cells: S8:S51, T8:T51, BH8:BH51, CS8:CS51)

BV = Operation time / EBCT **(5a.9)**

Water Quality Analysis

SDS-Chlorine Demand (Example cells: AH9:AH51, BR9:BR51, DC9:DC51)

(SDS-CD) = (SDS-Cl Dose) - (SDS-CR) **(5a.10)**

SDS-HAA5 (Example cells: BA9:BA51, CK9:CK51, DV9:DV51)

SDS-HAA5 = MCAA + DCAA + TCAA + MBAA + DBAA **(5a.11)**

SDS-HAA6 (Example cells: BB9:BB51, CL9:CL51, DW9:DW51)

SDS-HAA6 = MCAA + DCAA + TCAA + MBAA + DBAA + BCAA **(5a.12)**

SDS-THM4 (Example cells: AQ9:AQ51, CA9:CA51, DL9:DL51)

SDS-THM4 = CHCl3 + BDCM + DBCM + CHBr3 **(5a.13)**

Specific Ultraviolet Absorbance (Example cells: AE9:AE51, BO9:BO51, CZ9:CZ51)

$$\mathbf{SUVA = (UV_{245}/TOC) \times 100 (cm/m)} \qquad \textbf{(5a.14)}$$

6.0 Spreadsheets For Membrane RBSMT Bench-Scale Studies

The RBSMT spreadsheets are included in two files, and each file is designed to contain all of the data from four quarterly RBSMT studies evaluating *one* membrane. As summarized in Table 6-1, file *rbsmt-1.xls* is used to report the results from the evaluation of the first membrane, and file *rbsmt-2.xls* is used to report the results from the evaluation of the second membrane.

File name	Description
rbsmt-1.xls	RBSMT spreadsheet file used to report results for 1st membrane
rbsmt-2.xls	RBSMT spreadsheet file used to report results for 2nd membrane

Table 6-1 Summary Of RBSMT Spreadsheet Files

File *rbsmt-1.xls* contains five (5) field-sets, while *rbsmt-2.xls* contains four (4) field-sets. Each field-set is located on a separate worksheet, and Table 6-2 summarizes the designation, sheet title and cell range for each field-set. Each field-set is designed to contain the data from *one* quarterly RBSMT study evaluating *one* membrane. The extra field-set in *rbsmt-1.xls* is an Example Field-Set which demonstrates the use of the RBSMT spreadsheets. Example data are presented in each field to clarify the use of these spreadsheets and to verify that the spreadsheet equations are functioning properly. Field-Sets 1 through 4 are used to report the results from the four quarterly RBSMT studies.

Field-Set Title (Designation)	Sheet Title	Field-Set Cell Range
Example RBSMT Data (E-)	Sheet0. Example Data	A1:FC65
1st Quarter RBSMT Results (1-)	Sheet1. 1st Quarter	A1:FC99
2nd Quarter RBSMT Results (2-)	Sheet2. 2nd Quarter	A1:FC99
3rd Quarter RBSMT Results (3-)	Sheet3. 3rd Quarter	A1:FC99
4th Quarter RBSMT Results (4-)	Sheet4. 4th Quarter	A1:FC99

Table 6-2 Summary Of RBSMT Field-Sets And Corresponding Sheet Titles

Each field-set contains fifteen (15) fields which are identified by the field-set designation (i.e., E, 1, 2, 3 or 4) followed by a field designation (i.e., 1 through 15). For example, Field 1-6 is the sixth field in Field-Set 1, and Field 4-6 is the sixth field in Field-Set 4. Furthermore, fields with the same *field designation* are identical (e.g., Field 1-6 is the same as Field 4-6 except that Field 1-6 is used to report the first set of quarterly results, and Field 4-6 is used to report the fourth set of quarterly results). The field titles, designations and cell ranges are summarized in Table 6-3, and the individual fields are described in Sections 6.1 through 6.15.

Field Title	Designation	Field Cell Range
PWS and Treatment Plant Data	1	A3:B30
Manufacturer Reported Membrane Characteristics	2	D3:E42
RBSMT Design Parameters	3	G3:O20
Foulants and Fouling Indices	4	Q3:R29
Pretreatment Used Prior to Membranes	5	T3:V24
Feed Water Quality After Pretreatment	6	X3:AC46
Membrane Setting Data	7	AE3:AY46
Membrane Performance Data During Operation With The Test Water	8	BA3:CW99
Permeate And Concentrate Water Quality For Run 1	9	CY3:DJ50
Permeate And Concentrate Water Quality For Run 2	10	DL3:DT50
Permeate And Concentrate Water Quality For Run 3	11	DV3:ED50
Permeate And Concentrate Water Quality For Run 4	12	EF3:EN50
Blending Calculations For Stage 1 D-DBP MCLs	13	EP3:ET65
Blending Calculations For Proposed Stage 2 D-DBP MCLs	14	EV3:EZ65
Membrane Cost Parameters	15	FB3:FC20

Table 6-3 Summary Of RBSMT Data Fields

6.1 Field 1: PWS And Treatment Plant Data *(A3:B30)*

Exhibit 6-1 presents an example of Field 1 which is used to enter the Public Water System (PWS) and treatment plant data, including the PWSID#, plant ICR #, and addresses and phone numbers of the official and technical ICR contacts. Some of the information in Field 1 is optional (i.e., the WIDB number and e-mail addresses).

6.2 Field 2: Manufacturer Reported Membrane Characteristics *(D3:E42)*

Exhibit 6-2 presents an example of Field 2 which is used to enter the manufacturer reported characteristics of the membrane used in the RBSMT study. The first block of cells in Field 2, ***General Information (D4:E11)***, is used to report information including the membrane manufacturer, trade name, molecular weight cutoff, etc. The second block, ***Design Parameters (D13:E23)***, is used to enter values for the parameters that will be used in the design of the RBSMT studies, and all of the information in this block **must** be entered including:

- The design flux (F_W) in **gfd**.
- The net driving pressure (NDP) at this design flux in **psi**.
- The water mass transfer coefficient, or water flux per unit of net driving pressure (MTC_W) in **gfd/psi**. (If the MTC_W is not explicitly reported by the manufacturer, it can be calculated by dividing the design flux by the net driving pressure at this design flux.)
- The temperature (T°C) at which the design flux or MTC_W was measured in **°C**.
- The active membrane area of an equivalent 8" x 40" membrane element in **ft²**.
- The purchase price of an equivalent 8" x 40" membrane element in **$**.
- The maximum ($Q_{I,\,max}$) and minimum ($Q_{I,\,min}$) allowable flow rates to an 8" x 40" element in **gpm**.
- The total width of all membrane envelopes in the 8" x 40" element (w) in **ft** (i.e., this is the *width* of the feed flow channel in the membrane element).
- The thickness of the feed spacer used in the 8" x 40" element (T) in **ft** (i.e., this is the *thickness* of the feed flow channel in the membrane element). This feed spacer thickness should be identical to the thickness of the feed spacer used in the RBSMT cell.

The third block in this field ***(D25:E42)*** is used to enter additional information reported by the manufacturer such as the required feed flow to permeate flow rate ratio, the maximum element recovery, and any other information that could be used during the design of the RBSMT study.

6.3 Field 3: RBSMT Design Parameters ***(G3:O20)***

Exhibit 6-3 presents an example of Field 3 which defines the experimental matrix for the RBSMT study. In addition to the design parameters entered in Field 2, the following design parameters must be entered in the first block of Field 3, ***Input Design Parameters (G4:M10)*** to calculate the RBSMT experimental design:

- The active area of membrane in the bench-scale cell (i.e., the membrane area in contact with feed water) in **ft²**.
- The active width of membrane area in the bench-scale cell (i.e., the width of membrane in contact with feed water) in **ft**.
- The average yearly temperature of the feed water entering the full-scale plant in **°C**.
- The approximate feed water TDS in **mg/L**.
- The manufacturer reported TDS rejection expressed as a **decimal fraction**.
- The spreadsheet calculates the value of the MTC_W normalized to the average yearly water temperature in cell ***M10*** of this block.

In the next block, ***Experimental Design (G12:O20)***, the user enters the design flux, and the spreadsheet calculates the RBSMT operating parameters. The osmotic pressure gradient is estimated from the feed water TDS and TDS rejection. The required influent pressure is calculated along with the influent, permeate, feed and concentrate-waste flow rates. These flow rates and pressures are intended to provide a starting point for the simulation, and the concentrate-waste flow rate and influent pressure may need to be adjusted during the course of the run to obtain the desired recovery and permeate flux.

6.4 Field 4: Foulants And Fouling Indices ***(Q3:R29)***

Exhibit 6-4 shows an example of Field 4 which is used to report the concentrations of various foulants and the values of fouling indices for the feed water prior to pretreatment. Numerous water quality parameters that could constitute a fouling problem are included here, however only those parameters relevant to the water being tested need to be evaluated. Foulants and indices not listed in this field, but which are evaluated as part of the study, should be reported in the blank rows. The information in this field should be used to select appropriate pretreatment to membrane separations in order to minimize fouling.

6.5 Field 5: Pretreatment Used Prior To Membranes *(T3:V24)*

Field 5 is used to report all pretreatment processes used prior to the RBSMT test system, and Exhibit 6-5 presents an example of Field 5. All full-scale, pilot-scale and bench-scale pretreatment processes should be listed in this field. The process name should be entered, along with a brief description of the process (e.g., chemical dose, cartridge filter exclusion size, etc.) and the scale of the process (i.e., full-scale, pilot-scale or bench-scale). Detailed design information is not required in this spreadsheet since this design data will be included in the hard-copy *Treatment Study Summary Report* as described in Section 10.0 of this document. The purpose of Field 5 is to associate the pretreatment processes used during the RBSMT study with the data entered in the spreadsheet.

6.6 Field 6: Feed Water Quality After Pretreatment *(X3:AC46)*

Field 6 is used to report the water quality of the pretreated feed to the RBSMT system, and Exhibit 6-6 presents an example of Field 6. The feed water quality parameters include pH, temperature, alkalinity, total dissolved solids (TDS), total hardness, calcium hardness, turbidity, ammonia, total organic carbon (TOC), absorbance at ultra-violet 254 nm (UV_{254}), bromide, SDS-chlorine demand, SDS-TOX, SDS-THM4 and SDS-HAA6[1]. All feed water quality parameters must be sampled two (2) times for each batch of pretreated feed water, and the results of primary (C_F-1) and duplicate (C_F-2) analyses are entered into the third and fourth columns of Field 6. The spreadsheet calculates the average and relative percent difference for the primary and duplicate analyses. The spreadsheet also calculates the SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

A single batch of pretreated feed water must be large enough to conduct one set of quarterly studies on at least one membrane. It is advantageous to prepare a single batch of pretreated feed water large enough to run quarterly studies on two membranes since this will halve the feed water sampling requirements and facilitate comparison between the two membranes. If the same batch of feed water is used to test both membranes, simply enter the same results from the feed water analysis into Field 6 of the two spreadsheet files *rbsmt1.xls* and *rbsmt-2.xls*.

The date and time at which each feed water sample is collected, along with the operation time expressed in decimal hours, must be entered in Field 6. The operation time is defined

[1]Only six HAA species are required, but the additional three HAA species (TBAA, CDBAA and DCBAA) should be reported if measured.

with respect to the start date and time of RBSMT operation with the pretreated feed water. Any period of time during which system operation is interrupted must not be included in the cumulative operation time.

6.7 Field 7: Membrane Setting Data *(AE3:AY46)*

Exhibit 6-7 shows an example of Field 7 which is used to report the parameters monitored during setting. Setting is a period during which the membrane is operated with either laboratory-clean water or a salt solution in order to obtain a stable clean-water flux. (More information on membrane setting can be found in the *ICR Manual for Bench- and Pilot-Scale Treatment Studies*.)

At the top of this field, the average TDS rejection for the membrane being tested and the TDS concentration of the setting solution must be entered in cells ***AI5*** and ***AP5***, respectively. These values are used to estimate the osmotic pressure gradient during operation with the setting solution. If only deionized water is used during setting, the TDS concentration will be very low and the osmotic pressure negligible; however, if a salt solution is being used to set the membrane, the TDS concentration can be very high and the osmotic pressure significant.

In this field, the date, time, and setting time must be reported. The setting time is reported in decimal hours and is defined with respect to the starting date and time of RBSMT operation with the setting solution. Any period of time during which system operation is interrupted must not be included in the cumulative setting time. During setting, the influent temperature, pressure and flow rate are monitored along with the concentrate pressure and the permeate and concentrate-waste flow rates. **It is important to enter all measured parameters in the specified units: temperature in °C, pressure in psi and flow rate in mL/min.**

The spreadsheet uses these entered values to calculate operating parameters such as the feed flow rate, cross-flow velocity, recovery, water flux, temperature normalized water flux, net driving pressure and water mass transfer coefficient. The temperature normalized water flux is calculated using a generic temperature correction equation (see Equation 6a.13 in Appendix 6a). If a membrane specific temperature correction equation is provided by the manufacturer, it should be used instead of Equation 6a.13. To use a different temperature correction equation, overwrite the existing equation in cells ***AS9:AS46*** and ***BP9:BP99***, making sure that the revised equation references the proper cells. To overwrite an equation in the spreadsheet, the sheet must be Unprotected, and the cells containing the equation must be unLocked as described in Section 3.3.

6.8 Field 8: Membrane Performance Data During Operation With The Test Water *(BA3:CW99)*

Field 8 is used to report the parameters monitored during operation with the pretreated test water, and an example of Field 8 is shown in Exhibit 6-8. At the top of this field, the running average of the bulk TDS rejection is automatically calculated in cell ***BE5***. This average bulk TDS rejection is used to estimate the osmotic pressure gradient during operation with the pretreated test water.

Field 8 is similar to Field 7 in that various parameters are entered and used to calculate operating parameters such as the feed flow rate, cross-flow velocity, recovery, flux, temperature normalized flux, net driving pressure and water mass transfer coefficient. In Field 8, the operation time is reported in decimal hours and is set at 0.00 at the start of operation with the pretreated test water; thus, the setting time is **not** included in the cumulative operation time. Additionally, any period of time during which system operation is interrupted (e.g., during a cleaning event) must not be included in the cumulative operation time. Membrane cleaning events should be indicated with an "**X**" in column ***BJ*** of Field 8.

The temperature normalized flux is calculated using a generic temperature correction equation (see Equation 6a.13 in Appendix 6a). If a membrane specific temperature correction equation is provided by the manufacturer, it should be used instead of Equation 6a.13. To use a different temperature correction equation, overwrite the existing equation in cells **AS9:AS46** and **BP9:BP99**, making sure that the revised equation references the proper cells. To overwrite an equation in the spreadsheet, the sheet must be Unprotected, and the cells containing the equation must be unLocked as described in Section 3.3.

Field 8 is also used to report the feed, permeate and concentrate water quality parameters that are monitored with time: pH, TDS and UV_{254} (and TOC if measured). Since these water quality parameters do not need to be monitored every time a flow rate measurement is taken, some cells will be left empty. For those times at which a permeate sample is collected, the feed rejection (R_F), calculated concentrate concentration ($C_{C(calc)}$), bulk concentration (C_B) and bulk rejection (R_B) are calculated for TDS, UV_{254} and TOC. For sampling events when both permeate and concentrate water quality parameters are analyzed, the mass balance closure error ($Error_{MB}$) is also calculated.

6.9 Field 9: Permeate And Concentrate Water Quality For Run 1 *(CY3:DJ50)*

Field 9 is used to report the permeate and concentrate water quality for the first RBSMT run, and an example of Field 9 is shown in Exhibit 6-9. The date, time and operation time at which each permeate and concentrate sample is collected must be entered in Field 9. The following water quality parameters are to be analyzed and reported for permeate samples: pH, temperature, alkalinity, TDS, total hardness, calcium hardness, turbidity, ammonia, TOC, UV_{254}, bromide, SDS-chlorine demand, SDS-TOX, SDS-THM4 and SDS-HAA6. Additionally, water quality analyses must be duplicated for the permeate sample from the first RBSMT run. The spreadsheet will calculate the average concentration and relative percent difference for the primary and duplicate permeate concentrations entered in Field 9.

The following concentrate water quality parameters must be reported in Field 9: pH, temperature, alkalinity, TDS, total hardness, calcium hardness, turbidity, ammonia, TOC and UV_{254}. The spreadsheet will automatically calculate the mass balance closure error for these water quality parameters with the exceptions of pH and temperature.

The spreadsheet also calculates the concentrate concentration, feed rejection, bulk concentration and bulk rejection, as well as the SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

In order to calculate the mass balance closure error, bulk concentration, and bulk rejection, the following operating parameters must be entered in cells ***DA5:DA7*** of Field 9: the recovery, feed flow rate and influent flow rate. These operating parameters must reflect average system operation during the period over which the permeate and concentrate samples are collected. The recovery must be expressed as a decimal fraction and the flow rates must be expressed in mL/min.

6.10 Field 10: Permeate And Concentrate Water Quality For Run 2 *(DL3:DT50)*

Field 10 is used to report the permeate and concentrate water quality for the second RBSMT run under the second set of operating conditions, and an example of Field 10 is shown in Exhibit 6-10. Field 10 is identical to Field 9 except that Field 10 does not have columns for results from duplicate permeate analyses or the average and relative percent difference.

6.11 Field 11: Permeate And Concentrate Water Quality For Run 3 *(DV3:ED50)*

Field 11 is identical to Field 10 except that it is used to report the permeate and concentrate water quality for the third RBSMT run under the third set of operating conditions.

6.12 Field 12: Permeate And Concentrate Water Quality For Run 4 *(EF3:EN50)*

Field 12 is identical to Field 10 except that it is used to report the permeate and concentrate water quality for the fourth RBSMT run under the fourth set of operating conditions.

6.13 Field 13: Blending Calculations For Stage 1 D-DBP MCLs *(EP3:ET65)*

Exhibit 6-11 is an example of Field 13 which calculates the permeate flow to total product flow ratio (i.e., blend ratio) that can meet the Stage 1 D-DBP MCLs with a 10% factor of safety (i.e., 72 and 54 µg/L for THM4 and HAA5, respectively). No input is required in this field, however the output must be interpreted. In the first block of this field, ***Feed and Permeate Water Quality Parameters (EP4:ET26)***, the feed and permeate concentrations from each run are automatically copied into the appropriate cells of Field 13. The second block, ***Blended Water Quality If THM4 Controls the Blend Ratio (EP28:ET39)***, calculates the permeate to total product flow ratio (Q_p/Q_T) when 90% of the Stage 1 THM4 MCL (72 µg/L) controls the blend ratio. The third block, ***Blended Water Quality If HAA5 Controls the Blend Ratio (EP42:ET53)***, calculates this blend ratio when 90% of the Stage 1 HAA5 MCL (54 µg/L) controls the blend ratio. The second and third blocks then use the blend ratio to calculate the water quality of the feed/permeate blend. Blended water qualities are indicated by the subscript "b" and are calculated for SDS-THM4, SDS-HAA5, SDS-TOX, SDS-CD, TOC, UV_{254}, bromide, alkalinity, total hardness and calcium hardness.

In some cases, the blending calculations are meaningless. If the permeate concentration does not meet 90% of the DBP MCL prior to blending, then the blend ratio will be greater than 100% indicating that blending is not feasible. If the feed concentration meets 90% of the DBP MCL prior to blending then nanofiltration is not required to meet the MCL and the blend ratio will be negative. In both of these cases, the spreadsheet will report "NA" for the blended water quality parameters since the calculated values have no physical significance.

When the blending calculations are relevant, the user must compare the blend ratios calculated for THM4 and HAA5 since the higher blend ratio is the minimum ratio that will meet both MCLs with a 10% factor of safety. For example, in Exhibit 6-11, for runs 3 and 4 the THM4 MCL controls the blend ratio; while the blending calculations are meaningless for runs 1 and 2 since the permeate THM4 concentration exceeds 90% of the Stage 1 MCL in both cases.

6.14 Field 14: Blending Calculations For Proposed Stage 2 D-DBP MCLs *(EV3:EZ65)*

Field 14 is identical to Field 13 except that Field 14 calculates the permeate flow to total product flow ratio that can be used to meet the proposed Stage 2 D-DBP MCLs with a 10% factor of safety (i.e., 36 and 27 μg/L for THM4 and HAA5, respectively).

6.15 Field 15: Membrane Cost Parameters *(FB3:FC20)*

Field 15 is used to report the utility-specific cost parameters that are used to generate cost estimates for the use of membrane technology, and an example of Field 15 is shown in Exhibit 6-12. Example cost parameters are listed in Exhibit 6-12, but it is important to report cost parameters specific to the utility and not default or example values.

	A	B
3	**Field E-1: PWS And Treatment Plant Data**	
4		
5	PWS Name	Anytown Public Works
6	Public Water System Identification Number	OH1234567
7	Water Industry Data Base Number (*optional*)	######
8		
9	Official ICR Contact Person	Mr. Any Body
10	Mailing Address	#### Street
11		City, State Zip code
12	Phone Number	(###) ###-####
13	FAX Number	(###) ###-####
14	E-Mail Address (*optional*)	last.first@wtp.com
15		
16	Technical ICR Contact Person	Ms. Some One
17	Mailing Address	#### Street
18		City, State Zip code
19	Phone Number	(###) ###-####
20	FAX Number	(###) ###-####
21	E-Mail Address (*optional*)	last.first@wtp.com
22		
23	Plant Name	East WTP
24	Treatment Plant Category	CONV
25	Process Train Name	Conventional train
26	ICR Treatment Plant Identification Number	###
27	PWSID Number of Plant (*if assigned*)	Not assigned
28	Historical Minimum Water Temperature (^{o}C)	4.0
29	Historical Average Water Temperature (^{o}C)	18.0
30	State Approved Plant Capacity (MGD)	100.0
31		
32	**Exhibit 6-1 Example Of Field 1 For The RBSMT Data Sheet**	

	D	E
3	**Field E-2: Manufacturer Reported Membrane Characteristics**[1]	
4	***General Information***	
5	Membrane manufacturer	Company Name
6	Membrane trade name	NFPA-200
7	Molecular weight cutoff (Daltons)	200
8	Membrane material (e.g., PVD, polyamide, etc.)	polyamide
9	Membrane construction (e.g., thin-film composite)	thin-film composite
10	Membrane hydrophobicity	hydrophilic
11	Membrane charge (e.g., negative, highly negative, neutral, etc.)	highly negatively charged
12		
13	***Design Parameters***	
14	Design flux, F_W (gfd)	15.0
15	Net driving pressure at the design flux, NDP (psi)	80.0
16	Water mass transfer coefficient, MTC_W (gfd/psi)	0.188
17	Temperature at which the MTC_W was determined, T^oC (^oC)	25.0
18	Active membrane area of an equivalent 8" x 40" element (ft^2)	315.0
19	Purchase price for an equivalent 8" x 40 " element ($)	1000.00
20	Maximum flow rate to the 8" x 40" element, $Q_{I, max}$ (gpm)	75.0
21	Minimum flow rate to the 8" x 40" element, $Q_{I, min}$ (gpm)	15.0
22	Total width of all membrane envelopes in the 8" x 40" element, w (ft)	52.0
23	Feed spacer thickness in the 8" x 40" element, T (ft)	0.0025
24		
25	***Additional Information***	
26	Design cross-flow velocity (fps)	0.257
27	Required influent flow to permeate flow rate ratio, Q_I:Q_p	6:1
28	Maximum element recovery (%)	16
29	Variability of design flux (%)	15
30	Rejection of reference solute and conditions of test	90% rejection of a 2000 mg/L
31	(e.g., solute type and concentration)	$MgSO_4$ solution
32	Variability of rejection of reference solute (%)	1
33	Standard testing recovery (%)	15
34	Standard testing pH	7
35	Acceptable range of operating pressures	0 - 250
36	Acceptable range of operating pH values	3 - 9
37	Typical pressure drop across a single element (psi)	5
38	Maximum permissible SDI	5
39	Maximum permissible turbidity (ntu)	Not reported
40	Chlorine/oxidant tolerance (e.g., < 0.1 mg/L for extended use, etc.)	1.0 mg/L maximum
41	1: All of the information requested in this field may not be available, but values for all ***Design***	
42	***Parameters*** must be entered in cells E14:E23, since these parameters are used in calculations.	
43		
44	**Exhibit 6-2 Example Of Field 2 For The RBSMT Data Sheet**	

Field E-3: RBSMT Design Parameters

Input Design Parameters

Active membrane area in bench-scale cell, A_{cell} (ft^2)	0.167
Active width of membrane in the bench-scale cell, w_{cell} (ft)	0.333
Average yearly temperature of feed water, Tavg°C (°C)	18.0
Approximate feed water TDS, TDS_F (mg/L)	500.0
Manufacturer reported TDS rejection, Rej_{TDS} (decimal fraction)	0.70
Temperature normalized MTC_W (gfd/psi)	0.152

Experimental Design [1,2]

ID#	Recovery (decimal)	$F_{W\text{-design}}$ (gfd)	$\Delta\pi$ (psi)	P_I (psi)	$Q_{I\text{-cell}}$ (mL/min)	Q_p (mL/min)	Q_F (mL/min)	Q_W (mL/min)
1	0.70	15.0	13.2	112	364	6.6	9.4	2.8
2	0.90	15.0	36.5	135	364	6.6	7.3	0.7
3	0.50	15.0	8.5	107	364	6.6	13.1	6.6
4	0.30	15.0	6.5	105	364	6.6	21.9	15.3

1: For experimental matrix see Table 4-2 in Part 3 of the ICR Treatment Studies Manual.

2: Flow rates and pressures may need to be adjusted in order to obtain the desired operating conditions.

Exhibit 6-3 Example Of Field 3 For The RBSMT Data Sheet

	Q	R
3	**Field E-4: Foulants And Fouling Indices[1]**	
4	***Parameters Evaluated Prior to Pretreatment***	
5	Alkalinity (mg/L as $CaCO_3$)	40
6	Calcium Hardness (mg/L as $CaCO_3$)	79
7	LSI	1.4
8	Dissolved iron (mg/L)	15
9	Total iron (mg/L)	17
10	Dissolved aluminum (mg/L)	
11	Total aluminum (mg/L)	
12	Fluoride (mg/L)	
13	Phosphate (mg/L)	
14	Sulfate (mg/L)	
15	Calcium (mg/L)	
16	Barium (mg/L)	
17	Strontium (mg/L)	
18	Reactive silica (mg/L as SiO_2)	
19	Turbidity (ntu)	5
20	SDI	4
21	MFI	
22	MPFI	
23		
24		
25		
26		
27		
28	1: Only those foulants and fouling indices relevant to the water being tested need to	
29	be evaluated. Additional foulants and indices can be listed in the blank rows.	
30		
31	**Exhibit 6-4 Example Of Field 4 For The RBSMT Data Sheet**	

	T	U	V
3	**Field E-5: Pretreatment Used Prior To Membranes[1]**		
4			
5	**Process**	**Description**	**Scale**
6	Coagulation	50 $\pm$ 15 mg/L alum	Full-scale
7	Flocculation	2-stage	Full-scale
8	Sedimentation	tube settler	Full-scale
9	Dual media filtration	sand / anthracite	Full-scale
10	Cartridge filtration	2 um exclusion size	Bench-scale
11	Sulfuric acid addition	pH = 6.0	Bench-scale
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22	1: Design information, similar to that shown in Tables 6c and 6d of the ICR rule, must be included in		
23	the hard-copy *Treatment Study Summary Report* (see Section 10.0). The purpose of this table		
24	is to list the pretreatment processes used in this particular RBSMT run.		
25			
26	**Exhibit 6-5 Example Of Field 5 For The RBSMT Data Sheet**		

	X	Y	Z	AA	AB	AC
3	**Field E-6: Feed Water Quality After Pretreatment**					
4						
5	**Parameter**	**Units**	**C_F-1**	**C_F-2**	**Average**	**RPD**
6	Sampling date	MM/DD/YY	4/11/96	4/21/96	---	---
7	Sampling time	hh:mm	12:00	12:00	---	---
8	Operation time	hh.hh	0.00	240.00	---	---
9	pH	---	6.04	5.99	6.02	0.83
10	Temperature	^oC	22.0	24.0	23.0	8.70
11	Alkalinity	mg/L as $CaCO_3$	75.0	70.0	72.5	6.90
12	Total dissolved solids	mg/L	502.0	497.0	499.5	1.00
13	Total hardness	mg/L as $CaCO_3$	320.0	309.0	314.5	3.50
14	Calcium hardness	mg/L as $CaCO_3$	291.0	288.0	289.5	1.04
15	Turbidity	ntu	0.80	1.00	0.90	22.22
16	Ammonia	mg NH_3-N / L	4.2	4.6	4.4	9.09
17	Total organic carbon	mg/L	9.80	9.60	9.70	2.06
18	UV_{254}	cm^{-1}	0.338	0.324	0.331	4.23
19	SUVA	L/(mg*m)	3.45	3.38	3.41	2.17
20	Bromide	µg/L	250.0	253.0	251.5	1.19
21	SDS-Cl_2 dose	mg/L	13.10	13.20	13.15	0.76
22	SDS-Free Cl_2 residual	mg/L	0.90	1.30	1.10	36.36
23	SDS-Cl_2 demand	mg/L	12.20	11.90	12.05	2.49
24	SDS-Chlorination temp.	^oC	19.7	19.8	19.8	0.51
25	SDS-Chlorination pH	---	7.86	7.92	7.89	0.76
26	SDS-Incubation time	hours	84.5	84.4	84.5	0.12
27	SDS-TOX	µg Cl^- /L	1100.00	1050.00	1075.00	4.65
28	SDS-*CHCl3*	µg/L	205.00	198.00	201.50	3.47
29	SDS-*BDCM*	µg/L	54.90	57.20	56.05	4.10
30	SDS-*DBCM*	µg/L	12.30	13.90	13.10	12.21
31	SDS-*CHBr3*	µg/L	0.37	0.59	0.48	45.83
32	SDS-THM4	µg/L	272.57	269.69	271.13	1.06
33	SDS-*MCAA**	µg/L	5.04	4.78	4.91	5.30
34	SDS-*DCAA**	µg/L	39.30	41.30	40.30	4.96
35	SDS-*TCAA**	µg/L	83.90	86.30	85.10	2.82
36	SDS-*MBAA**	µg/L	BMRL	0.67	0.67	#VALUE!
37	SDS-*DBAA**	µg/L	3.33	4.21	3.77	23.34
38	SDS-*BCAA**	µg/L	28.00	32.50	30.25	14.88
39	SDS-*TBAA*	µg/L	NA	NA	#DIV/0!	#VALUE!
40	SDS-*CDBAA*	µg/L	NA	NA	#DIV/0!	#VALUE!
41	SDS-*DCBAA*	µg/L	NA	NA	#DIV/0!	#VALUE!
42	SDS-HAA5	µg/L	131.57	137.26	134.42	4.23
43	SDS-HAA6	µg/L	159.57	169.76	164.67	6.19
44	BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported					
45	*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA,					
46	should be reported if measured.					
47						
48	**Exhibit 6-6 Example Of Field 6 For The RBSMT Data Sheet**					

	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY
3	**Field E-7: Membrane Setting Data**																				
4																					
5	**Average TDS rejection (decimal fraction)**				**0.67**			**TDS concentration of setting solution (mg/L)**				**2000.0**									
6																					
7	Date	Time	Setting time	Influent	P_I	P_C	Q_I	Q_p	Q_W	Q_F	v_c	Recovery	Recycle	F_W (T°C)	F_W (Tavg°C)	TDS_W	TDS_p	TDS_I	$\Delta\pi$	NDP	MTC_W (Tavg°C)
8	MM/DD/YY	hh:mm	hh.hh	Temp. (°C)	(psi)	(psi)	(mL/min)	(mL/min)	(mL/min)	(mL/min)	(fps)	(decimal)	ratio	(gfd)	(gfd)	(mg/L)	(mg/L)	(mg/L)	(psi)	(psi)	(gfd/psi)
9	4/9/96	11:00	0.00	22.1	100.0	100.0	365.0	6.09	33.90	39.99	0.258	0.15	8.13	13.90	12.31	2228.7	727.2	2203.6	14.9	85.1	0.145
10	4/9/96	11:30	0.50	22.2	99.0	99.0	360.0	6.11	34.00	40.11	0.254	0.15	7.98	13.95	12.32	2228.8	727.1	2203.3	14.9	84.1	0.146
11	4/9/96	12:00	1.00	22.1	100.0	100.0	360.0	6.15	34.00	40.15	0.254	0.15	7.97	14.04	12.43	2230.2	727.5	2204.5	14.9	85.1	0.146
12	4/9/96	13:00	2.00	22.0	100.0	100.0	355.0	6.24	34.20	40.44	0.251	0.15	7.78	14.24	12.65	2232.1	727.9	2205.7	14.9	85.1	0.149
13	4/9/96	15:00	4.00	22.2	99.0	99.0	370.0	6.18	34.00	40.18	0.261	0.15	8.21	14.11	12.46	2231.2	728.0	2206.1	14.9	84.1	0.148
14	4/9/96	19:00	8.00	22.4	101.0	101.0	365.0	6.20	34.10	40.30	0.258	0.15	8.06	14.15	12.43	2231.3	727.9	2205.8	14.9	86.1	0.144
15	4/9/96	23:00	12.00	22.4	100.0	100.0	365.0	6.31	34.10	40.41	0.258	0.16	8.03	14.40	12.65	2235.2	729.0	2209.1	14.9	85.1	0.149
16	4/10/96	3:00	16.00	22.3	100.0	100.0	375.0	6.33	33.90	40.23	0.265	0.16	8.32	14.45	12.72	2237.2	729.9	2211.7	14.9	85.1	0.150
17	4/10/96	7:00	20.00	22.4	100.0	100.0	375.0	6.29	34.00	40.29	0.265	0.16	8.31	14.36	12.61	2235.1	729.2	2209.8	14.9	85.1	0.148
18	4/10/96	11:00	24.00	22.5	99.0	99.0	372.0	6.38	34.20	40.58	0.263	0.16	8.17	14.56	12.75	2237.0	729.7	2211.1	14.9	84.1	0.152
19	4/10/96	15:00	28.00	22.3	101.0	101.0	370.0	6.40	34.10	40.50	0.261	0.16	8.14	14.61	12.86	2238.3	730.0	2212.3	15.0	86.0	0.150
20	4/10/96	19:00	32.00	22.0	100.0	100.0	365.0	6.33	34.00	40.33	0.258	0.16	8.05	14.45	12.84	2236.5	729.4	2210.4	14.9	85.1	0.151
21	4/10/96	23:00	36.00	22.1	100.0	100.0	365.0	6.42	34.00	40.42	0.258	0.16	8.03	14.65	12.98	2239.7	730.4	2213.2	15.0	85.0	0.153
22	4/11/96	3:00	40.00	22.2	101.0	101.0	360.0	6.39	33.80	40.19	0.254	0.16	7.96	14.58	12.88	2240.0	730.4	2213.2	15.0	86.0	0.150
23	4/11/96	7:00	44.00	22.4	100.0	100.0	363.0	6.40	33.90	40.30	0.256	0.16	8.01	14.61	12.83	2239.7	730.3	2213.1	15.0	85.0	0.151
24	4/11/96	11:00	48.00	22.4	99.0	99.0	365.0	6.40	34.00	40.40	0.258	0.16	8.03	14.61	12.83	2239.0	730.1	2212.6	15.0	84.0	0.153
25										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
26										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
27										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
28										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
29										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
30										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
31										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
32										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
33										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
34										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
35										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
36										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
37										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
38										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
39										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
40										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
41										0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
42																					
43	**Exhibit 6-7 Example Of Field 7 For The RBSMT Data Sheet**																				

	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ
3	**Field E-8: Membrane Performance Data During Operation With The Test Water**																
4																	
5	**Average bulk TDS rejection (decimal fraction)**				**0.73**												
6																	
7	Date	Time	Operation time	Influent	P_I	P_C	Q_I	Q_p	Q_W	Cleaning Event	Q_F	v_c	Recovery	Recycle	F_W (T^oC)	F_W ($Tavg^oC$)	TDS_W
8	MM/DD/YY	hh:mm	hh.hh	Temp. (^oC)	(psi)	(psi)	(mL/min)	(mL/min)	(mL/min)	Indicate with "**X**"	(mL/min)	(fps)	(decimal)	ratio	(gfd)	(gfd)	(mg/L)
9	4/11/96	12:00	0.00	22.2	100.0	100.0	363.0	6.42	2.68		9.10	0.256	0.71	38.89	14.65	12.94	1036.40
10	4/11/96	12:30	0.50	22.4	100.0	100.0	364.0	6.40	2.70		9.10	0.257	0.70	39.00	14.61	12.83	1032.91
11	4/11/96	13:00	1.00	22.4	99.0	99.0	365.0	6.35	2.70		9.05	0.258	0.70	39.33	14.49	12.73	1030.29
12	4/11/96	14:00	2.00	22.6	100.0	100.0	365.0	6.32	2.69		9.01	0.258	0.70	39.51	14.43	12.59	1029.93
13	4/11/96	16:00	4.00	22.4	100.0	100.0	360.0	6.28	2.69		8.97	0.254	0.70	39.13	14.33	12.59	1027.90
14	4/11/96	20:00	8.00	22.0	100.0	100.0	363.0	6.24	2.70		8.94	0.256	0.70	39.60	14.24	12.65	1024.53
15	4/12/96	0:00	12.00	22.1	100.0	100.0	364.0	6.22	2.70		8.92	0.257	0.70	39.81	14.20	12.58	1023.46
16	4/12/96	4:00	16.00	22.1	101.0	101.0	364.0	6.20	2.72		8.92	0.257	0.70	39.81	14.15	12.54	1020.00
17	4/12/96	8:00	20.00	22.4	100.0	100.0	364.0	6.19	2.71		8.90	0.257	0.70	39.90	14.13	12.41	1020.67
18	4/12/96	12:00	24.00	22.4	100.0	100.0	365.0	6.20	2.72		8.92	0.258	0.70	39.92	14.15	12.43	1019.99
19	4/12/96	16:00	28.00	22.5	100.0	100.0	365.0	6.19	2.72		8.91	0.258	0.69	39.97	14.13	12.37	1019.46
20	4/12/96	20:00	32.00	22.6	100.0	100.0	365.0	6.18	2.70		8.88	0.258	0.70	40.10	14.11	12.31	1021.32
21	4/13/96	0:00	36.00	22.6	99.0	99.0	366.0	6.17	2.70		8.87	0.259	0.70	40.26	14.08	12.29	1020.77
22	4/13/96	4:00	40.00	22.4	100.0	100.0	365.0	6.15	2.70		8.85	0.258	0.69	40.24	14.04	12.33	1019.72
23	4/13/96	8:00	44.00	22.3	100.0	100.0	367.0	6.14	2.70		8.84	0.259	0.69	40.52	14.01	12.34	1019.16
24	4/13/96	12:00	48.00	22.4	100.0	100.0	365.0	6.12	2.71		8.83	0.258	0.69	40.34	13.97	12.27	1016.92
25	4/13/96	16:00	52.00	22.4	100.0	100.0	362.0	6.11	2.68		8.79	0.256	0.70	40.18	13.95	12.24	1020.02
26	4/13/96	20:00	56.00	22.1	100.0	100.0	365.0	6.10	2.70		8.80	0.258	0.69	40.48	13.92	12.33	1017.04
27	4/14/96	0:00	60.00	22.4	100.0	100.0	365.0	6.10	2.70		8.80	0.258	0.69	40.48	13.92	12.22	1017.04
28	4/14/96	4:00	64.00	22.4	100.0	100.0	366.0	6.09	2.70		8.79	0.259	0.69	40.64	13.90	12.20	1016.49
29	4/14/96	8:00	68.00	22.2	100.0	100.0	366.0	6.10	2.69		8.79	0.259	0.69	40.64	13.92	12.30	1018.22
30	4/14/96	12:00	72.00	22.2	100.0	100.0	366.0	6.09	2.69		8.78	0.259	0.69	40.69	13.90	12.28	1017.69
31	4/14/96	16:00	76.00	22.3	100.0	100.0	365.0	6.09	2.70		8.79	0.258	0.69	40.52	13.90	12.24	1016.50
32	4/14/96	20:00	80.00	22.4	103.0	103.0	365.0	6.08	0.79		6.87	0.258	0.89	52.13	13.88	12.18	1425.83
33	4/15/96	0:00	84.00	22.4	104.0	104.0	365.0	6.09	0.80		6.89	0.258	0.88	51.98	13.90	12.20	1422.52
34	4/15/96	4:00	88.00	22.1	103.0	103.0	364.0	6.10	0.82		6.92	0.257	0.88	51.60	13.92	12.33	1415.51
35	4/15/96	8:00	92.00	22.2	103.0	103.0	364.0	6.10	0.80		6.90	0.257	0.88	51.75	13.92	12.30	1423.07
36	4/15/96	12:00	96.00	22.5	98.0	98.0	363.0	6.09	6.11		12.20	0.256	0.50	28.75	13.90	12.17	788.42
37	4/15/96	16:00	100.00	22.5	98.0	98.0	365.0	6.09	6.09		12.18	0.258	0.50	28.97	13.90	12.17	789.16
38	4/15/96	20:00	104.00	22.4	98.0	98.0	365.0	6.08	6.10		12.18	0.258	0.50	28.97	13.88	12.18	788.41
39	4/16/96	0:00	108.00	22.4	98.0	98.0	362.0	6.08	6.10		12.18	0.256	0.50	28.72	13.88	12.18	788.42
40	4/16/96	4:00	112.00	22.6	97.0	97.0	365.0	6.08	14.03		20.11	0.258	0.30	17.15	13.88	12.11	641.98
41	4/16/96	8:00	116.00	22.4	97.0	97.0	365.0	6.08	14.01		20.09	0.258	0.30	17.17	13.88	12.18	642.17
42	4/16/96	12:00	120.00	22.4	97.0	97.0	365.0	6.08	14.02		20.10	0.258	0.30	17.16	13.88	12.18	642.08
43	4/16/96	16:00	124.00	22.3	97.0	97.0	364.0	6.08	14.00		20.08	0.257	0.30	17.13	13.88	12.22	642.26
44	4/16/96	20:00	128.00	22.4	97.0	97.0	366.0	6.08	14.00	**X**	20.08	0.259	0.30	17.23	13.88	12.18	642.26
45	4/16/96	21:00	129.00	22.1	97.0	97.0	365.0	6.45	14.01		20.46	0.258	0.32	16.84	14.72	13.04	649.96
46											0.00	0.000	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!
47																	
48	**Exhibit 6-8 Example Of Field 8 For The RBSMT Data Sheet (page 1 of 3)**																

Field E-8: Membrane Performance Data During Operation With The Test Water (continued)

	BR	BS	BT	BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK
7	TDS_p	TDS_I	$\Delta\pi$	NDP	MTC_W (Tavg°C)	pH			TDS (mg/L)											
8	(mg/L)	(mg/L)	(psi)	(psi)	(gfd/psi)	pH_p	pH_F	pH_C	TDS_p	TDS_F	TDS_C	$TDS_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	TDS_B	R_B (%)	UV_p	UV_F	UV_C	$UV_{C(calc)}$
9	275.37	1022.94	7.5	92.5	0.140	5.49	6.05	6.34												
10	274.47	1019.57	7.5	92.5	0.139	5.50	6.10	6.35	294.00			986.61		41.1	980.52	70.0	0.036			1.030
11	273.81	1017.13	7.5	91.5	0.139	5.61	6.11	6.30												
12	273.73	1016.84	7.5	92.5	0.136	5.45	6.03	6.30	287.00	505.00	1040.00	998.76	3.97	42.5	992.59	71.1	0.033	0.331	1.011	1.031
13	273.16	1014.73	7.5	92.5	0.136	5.50	6.00	6.38												
14	272.32	1011.60	7.5	92.5	0.137	5.53	6.00	6.22	282.00			1002.17		43.5	995.98	71.7	0.031			1.024
15	272.06	1010.62	7.4	92.6	0.136	5.55	6.02	6.24	277.00	498.00	1038.00	1012.07	2.50	44.5	1005.79	72.5	0.032	0.330	1.069	1.020
16	271.15	1007.25	7.4	93.6	0.134	5.50	6.03	6.20	275.00			1011.23		44.9	1004.96	72.6	0.030			1.017
17	271.33	1007.92	7.4	92.6	0.134	5.67	6.03	6.20												
18	271.16	1007.27	7.4	92.6	0.134	5.50	6.05	6.45	272.00			1018.07		45.5	1011.73	73.1	0.028			1.022
19	271.02	1006.77	7.4	92.6	0.134	5.44	6.00	6.44												
20	271.52	1008.62	7.4	92.6	0.133	5.56	6.00	6.50	270.00			1024.80		45.9	1018.41	73.5	0.029			1.022
21	271.39	1008.14	7.4	91.6	0.134	5.58	6.12	6.38	271.00	502.00	1022.00	1021.66	0.03	45.7	1015.34	73.3	0.028	0.332	1.087	1.023
22	271.11	1007.11	7.4	92.6	0.133	5.51	6.08	6.33	270.00			1022.25		45.9	1015.91	73.4	0.028			1.021
23	270.99	1006.64	7.4	92.6	0.133	5.53	5.98	6.30												
24	270.38	1004.40	7.4	92.6	0.132	5.52	6.00	6.30	270.00	498.00	1025.00	1017.78	0.70	45.9	1011.51	73.3	0.028	0.332	1.003	1.015
25	271.19	1007.38	7.4	92.6	0.132	5.52	6.00	6.34												
26	270.43	1004.56	7.4	92.6	0.133	5.50	5.99	6.34	270.00			1018.00		45.9	1011.75	73.3	0.028			1.016
27	270.43	1004.56	7.4	92.6	0.132	5.50	6.01	6.30												
28	270.29	1004.07	7.4	92.6	0.132	5.58	6.04	6.30	270.00			1017.15		45.9	1010.93	73.3	0.028			1.014
29	270.75	1005.77	7.4	92.6	0.133	5.61	6.03	6.41												
30	270.61	1005.26	7.4	92.6	0.133	5.64	6.00	6.44	270.00			1019.07		45.9	1012.84	73.3	0.028			1.017
31	270.29	1004.05	7.4	92.6	0.132	5.56	6.00	6.40	270.00	489.00	1039.00	1017.15	2.10	45.9	1010.92	73.3	0.028	0.329	1.120	1.014
32	379.14	1408.39	10.4	92.6	0.132	5.50	6.03	6.30	375.00			1457.68		24.9	1448.66	74.1	0.065			2.378
33	378.25	1405.09	10.4	93.6	0.130	5.50	6.00	6.25	376.00	493.00	1416.00	1439.64	-1.67	24.7	1430.77	73.7	0.066	0.330	2.460	2.348
34	376.36	1398.09	10.3	92.7	0.133	5.21	6.01	6.28												
35	378.38	1405.56	10.4	92.6	0.133	5.38	6.03	6.30	375.00			1448.81		24.9	1439.81	74.0	0.065			2.359
36	209.63	778.71	5.7	92.3	0.132	5.34	6.11	6.30	208.00	498.00	784.00	790.05	-0.77	58.4	785.16	73.5	0.017	0.331	0.658	0.644
37	209.84	779.50	5.7	92.3	0.132	5.67	6.00	6.24												
38	209.64	778.77	5.7	92.3	0.132	5.54	6.00	6.30	210.00			788.05		58.0	783.24	73.2	0.019			0.642
39	209.63	778.70	5.7	92.3	0.132	5.50	6.03	6.24	209.00	503.00	788.00	789.05	-0.13	58.2	784.18	73.3	0.018	0.332	0.635	0.643
40	170.71	634.13	4.7	92.3	0.131	5.50	5.98	6.30	169.00			642.72		66.2	638.78	73.5	0.012			0.469
41	170.76	634.31	4.7	92.3	0.132	5.54	5.97	6.29	171.00	501.00	648.00	642.06	0.92	65.8	638.14	73.2	0.012	0.330	0.460	0.469
42	170.73	634.22	4.7	92.3	0.132	5.50	6.00	6.30												
43	170.78	634.38	4.7	92.3	0.132	5.50	6.00	6.27	171.00	500.00	650.00	642.16	1.21	65.8	638.23	73.2	0.013	0.328	0.470	0.469
44	170.79	634.42	4.7	92.3	0.132	5.57	6.09	6.30	170.00			642.60		66.0	638.67	73.4	0.013			0.469
45	172.70	641.52	4.7	92.3	0.141	5.48	6.03	6.24	168.00			652.12		66.4	647.84	74.1	0.014			0.477
46	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!															

Exhibit 6-8 Example Of Field 8 For The RBSMT Data Sheet (page 2 of 3)

	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU	CV	CW
3	**Field E-8: Membrane Performance Data During Operation With The Test Water (continued)**											
4												
5												
6												
7	UV_{254} (cm^{-1})				TOC (mg/L), *Optional*							
8	$Error_{MB}$ (%)	R_F (%)	UV_B	R_B (%)	TOC_p	TOC_F	TOC_C	$TOC_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	TOC_B	R_B (%)
9												
10		89.1	1.022	96.5	2.34			27.15		75.9	26.93	91.3
11												
12	-1.99	90.0	1.022	96.8	2.22	9.80	26.90	27.27	-1.39	77.1	27.06	91.8
13												
14		90.6	1.016	96.9	2.18			27.08		77.5	26.87	91.9
15	4.60	90.3	1.011	96.8	2.13	9.90	28.10	27.14	3.42	78.0	26.93	92.1
16		90.9	1.009	97.0	2.07			27.09		78.7	26.88	92.3
17												
18		91.5	1.013	97.2	2.03			27.18		79.1	26.97	92.5
19												
20		91.2	1.014	97.1	1.98			27.37		79.6	27.16	92.7
21	5.85	91.5	1.015	97.2	2.00	9.80	26.40	27.30	-3.39	79.4	27.08	92.6
22		91.5	1.013	97.2	1.99			27.26		79.5	27.05	92.6
23												
24	-1.22	91.5	1.007	97.2	2.00	9.85	27.90	27.09	2.91	79.4	26.88	92.6
25												
26		91.5	1.007	97.2	2.00			27.10		79.4	26.89	92.6
27												
28		91.5	1.006	97.2	2.02			27.02		79.2	26.81	92.5
29												
30		91.5	1.009	97.2	2.00			27.13		79.4	26.92	92.6
31	9.43	91.5	1.006	97.2	2.00	10.00	26.30	27.07	-2.92	79.4	26.86	92.6
32		80.4	2.359	97.2	3.96			53.88		59.2	53.46	92.6
33	4.54	80.1	2.329	97.2	4.00	9.90	51.00	53.09	-4.10	58.8	52.68	92.4
34												
35		80.4	2.340	97.2	4.01			53.09		58.7	52.68	92.4
36	2.13	94.9	0.639	97.3	1.40	9.95	18.30	17.97	1.79	85.6	17.83	92.1
37												
38		94.3	0.637	97.0	4.98			14.40		48.7	14.33	65.2
39	-1.26	94.6	0.638	97.2	1.40	9.85	17.80	17.97	-0.97	85.6	17.83	92.1
40		96.4	0.465	97.4	1.12			13.42		88.5	13.32	91.6
41	-2.05	96.4	0.466	97.4	1.10	9.90	13.20	13.43	-1.76	88.7	13.33	91.7
42												
43	0.19	96.1	0.465	97.2	1.09	9.90	13.50	13.44	0.45	88.8	13.34	91.8
44		96.1	0.465	97.2	1.10			13.43		88.7	13.33	91.7
45		95.8	0.473	97.0	1.11			13.65		88.6	13.54	91.8
46												
47												
48	**Exhibit 6-8 Example Of Field 8 For The RBSMT Data Sheet (page 3 of 3)**											

	CY	CZ	DA
3	**Field E-9: Permeate And Concentrate Water Quality For Run 1**		
4	***Operating Parameters During Sample Collection***		
5	Recovery during sample collection (decimal)		0.70
6	Feed flow rate during sample collection (mL/min)		8.90
7	Influent flow rate during sample collection (mL/min)		365.00
8			
9	***Permeate and Concentrate Water Quality***		

	CY	CZ	DA	DB	DC	DD	DE	DF	DG	DH	DI	DJ
10	**Parameter**	**Units**	**C_p-1**	**C_p-1 (dup)**	**Average**	**RPD**	**C_C-1**	**$C_{C(calc)}$**	**$Error_{MB}$ (%)**	**R_F (%)**	**C_B**	**R_B (%)**
11	Sampling date	MM/DD/YY	4/14/96	4/14/96	---	---	4/14/96	---	---	---	---	---
12	Sampling time	hh:mm	12:00	12:00	---	---	12:00	---	---	---	---	---
13	Operation time	hh.hh	72.00	72.00	---	---	72.00	---	---	---	---	---
14	pH	---	5.62	5.66	5.64	0.71	6.44	---	---	---	---	---
15	Temperature	^oC	22.3	22.1	22.2	0.90	22.3	---	---	---	---	---
16	Alkalinity	mg/L as $CaCO_3$	14.0	16.0	15.0	13.33	210.0	206.7	1.59	79.3	205.0	92.7
17	Total dissolved solids	mg/L	272.0	268.0	270.0	1.48	1040.0	1035.0	0.48	45.9	1028.5	73.7
18	Total hardness	mg/L as $CaCO_3$	32.0	30.0	31.0	6.45	968.0	976.0	-0.83	90.1	967.9	96.8
19	Calcium hardness	mg/L as $CaCO_3$	27.0	30.0	28.5	10.53	891.0	898.5	-0.84	90.2	891.1	96.8
20	Turbidity	ntu	0.10	0.10	0.10	0.00	3.00	2.77	7.78	88.9	2.74	96.4
21	Ammonia	mg NH_3-N / L	1.2	1.0	1.08	23.26	12.0	12.2	-1.32	75.6	12.1	91.1
22	Total organic carbon	mg/L	1.90	2.00	1.95	5.13	27.40	27.78	-1.40	79.9	27.56	92.9
23	UV_{254}	cm^{-1}	0.027	0.029	0.028	7.14	1.050	1.038	1.14	91.5	1.029	97.3
24	SUVA	L/(mg*m)	1.42	1.45	1.44	2.02	3.83	---	---	---	---	---
25	Bromide	µg/L	151.0	152.0	151.5	0.66	---	484.8	---	39.8	482.0	68.6
26	SDS-Cl_2 dose	mg/L	2.40	2.50	2.45	4.08	---	---	---	---	---	---
27	SDS-Free Cl_2 residual	mg/L	0.90	1.00	0.95	10.53	---	---	---	---	---	---
28	SDS-Cl_2 demand	mg/L	1.50	1.50	1.50	0.00	---	36.67	---	87.6	36.37	95.9
29	SDS-Chlorination temp.	^oC	18.6	18.7	18.7	0.54	---	---	---	---	---	---
30	SDS-Chlorination pH	---	7.91	7.88	7.90	0.38	---	---	---	---	---	---
31	SDS-Incubation time	hours	85.2	85.3	85.3	0.12	---	---	---	---	---	---
32	SDS-TOX	µg Cl^- /L	80.00	75.00	77.50	6.45	---	3402.50	---	92.8	3374.12	97.7
33	SDS-*CHCl3*	µg/L	24.00	23.20	23.60	3.39	---	616.60	---	88.3	611.54	96.1
34	SDS-*BDCM*	µg/L	23.20	25.00	24.10	7.47	---	130.60	---	57.0	129.69	81.4
35	SDS-*DBCM*	µg/L	21.30	21.20	21.25	0.47	---	-5.92	---	-62.2	-5.68	473.8
36	SDS-*CHBr3*	µg/L	3.33	3.85	3.59	14.48	---	-6.78	---	-647.9	-6.69	153.7
37	SDS-THM4	µg/L	71.83	73.25	72.54	1.96	---	734.51	---	73.2	728.86	90.0
38	SDS-*MCAA**	µg/L	BMRL	1.35	1.35	#VALUE!	---	13.22	---	72.5	13.12	89.7
39	SDS-*DCAA**	µg/L	7.85	7.70	7.78	1.93	---	116.19	---	80.7	115.27	93.3
40	SDS-*TCAA**	µg/L	11.60	12.18	11.89	4.88	---	255.92	---	86.0	253.84	95.3
41	SDS-*MBAA**	µg/L	BMRL	BMRL	#DIV/0!	#VALUE!	---	#DIV/0!	---	#DIV/0!	#DIV/0!	#DIV/0!
42	SDS-*DBAA**	µg/L	5.75	6.09	5.92	5.74	---	-1.25	---	-57.0	-1.19	599.4
43	SDS-*BCAA**	µg/L	13.70	12.30	13.00	10.77	---	70.50	---	57.0	70.01	81.4
44	SDS-*TBAA*	µg/L	NA	NA	#DIV/0!	#VALUE!	---	#DIV/0!	---	#DIV/0!	#DIV/0!	#DIV/0!
45	SDS-*CDBAA*	µg/L	NA	NA	#DIV/0!	#VALUE!	---	#DIV/0!	---	#DIV/0!	#DIV/0!	#DIV/0!
46	SDS-*DCBAA*	µg/L	NA	NA	#DIV/0!	#VALUE!	---	#DIV/0!	---	#DIV/0!	#DIV/0!	#DIV/0!
47	SDS-HAA5	µg/L	25.20	27.32	26.26	8.07	---	386.78	---	80.5	383.70	93.2
48	SDS-HAA6	µg/L	38.90	39.62	39.26	1.83	---	457.28	---	76.2	453.71	91.3

49 BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

50 *: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

51

52 **Exhibit 6-9 Example Of Field 9 For The RBSMT Data Sheet**

	DL	DM	DN	DO	DP	DQ	DR	DS	DT
3	**Field E-10: Permeate And Concentrate Water Quality For Run 2**								
4	***Operating Parameters During Sample Collection***								
5	Recovery during sample collection (decimal)		0.88						
6	Feed flow rate during sample collection (mL/min)		6.89						
7	uent flow rate during sample collection (mL/min)		364.00						
8									
9	***Permeate and Concentrate Water Quality***								
10	**Parameter**	**Units**	**C_p-2**	**C_C-2**	**$C_{C(calc)}$**	**$Error_{MB}$ (%)**	**R_F (%)**	**C_B**	**R_B (%)**
11	Sampling date	MM/DD/YY	4/15/96	4/15/96	---	---	---	---	---
12	Sampling time	hh:mm	4:00	4:00	---	---	---	---	---
13	Operation time	hh.hh	88.00	88.00	---	---	---	---	---
14	pH	---	5.21	6.28	---	---	---	---	---
15	Temperature	^oC	22.1	22.2	---	---	---	---	---
16	Alkalinity	mg/L as $CaCO_3$	28.0	405.0	398.8	1.52	61.4	395.7	92.9
17	Total dissolved solids	mg/L	380.0	1400.0	1375.8	1.73	23.9	1367.5	72.2
18	Total hardness	mg/L as $CaCO_3$	70.0	2243.0	2107.5	6.04	77.7	2090.5	96.7
19	Calcium hardness	mg/L as $CaCO_3$	52.0	2100.0	2031.2	3.28	82.0	2014.7	97.4
20	Turbidity	ntu	0.10	6.90	6.77	1.93	88.9	6.71	98.5
21	Ammonia	mg NH_3-N / L	1.8	22.0	23.47	-6.67	59.1	23.29	92.3
22	Total organic carbon	mg/L	3.60	52.10	54.43	-4.48	62.9	54.01	93.3
23	UV_{254}	cm^{-1}	0.050	2.500	2.392	4.33	84.9	2.372	97.9
24	SUVA	L/(mg*m)	1.39	4.80	---	---	---	---	---
25	Bromide	µg/L	200.0	---	629.2	---	20.5	625.6	68.0
26	SDS-Cl_2 dose	mg/L	4.50	---	---	---	---	---	---
27	SDS-Free Cl_2 residual	mg/L	1.00	---	---	---	---	---	---
28	SDS-Cl_2 demand	mg/L	3.50	---	74.75	---	71.0	74.16	95.3
29	SDS-Chlorination temp.	^oC	18.6	---	---	---	---	---	---
30	SDS-Chlorination pH	---	7.91	---	---	---	---	---	---
31	SDS-Incubation time	hours	85.2	---	---	---	---	---	---
32	SDS-TOX	µg Cl^-/L	170.00	---	7711.67	---	84.2	7648.86	97.8
33	SDS-*CHCl3*	µg/L	43.20	---	1362.37	---	78.6	1351.38	96.8
34	SDS-*BDCM*	µg/L	34.80	---	211.88	---	37.9	210.41	83.5
35	SDS-*DBCM*	µg/L	24.90	---	-73.43	---	-90.1	-72.61	134.3
36	SDS-*CHBr3*	µg/L	4.15	---	-26.43	---	-764.6	-26.18	115.9
37	SDS-THM4	µg/L	107.05	---	1474.38	---	60.5	1463.00	92.7
38	SDS-*MCAA**	µg/L	2.90	---	19.65	---	40.9	19.51	85.1
39	SDS-*DCAA**	µg/L	13.20	---	239.03	---	67.2	237.15	94.4
40	SDS-*TCAA**	µg/L	18.30	---	574.97	---	78.5	570.33	96.8
41	SDS-*MBAA**	µg/L	1.16	---	-2.92	---	-73.1	-2.89	140.1
42	SDS-*DBAA**	µg/L	6.94	---	-19.48	---	-84.1	-19.26	136.0
43	SDS-*BCAA**	µg/L	18.50	---	116.42	---	38.8	115.60	84.0
44	SDS-*TBAA*	µg/L	NA	---	#DIV/0!	---	#DIV/0!	#DIV/0!	#DIV/0!
45	SDS-*CDBAA*	µg/L	NA	---	#DIV/0!	---	#DIV/0!	#DIV/0!	#DIV/0!
46	SDS-*DCBAA*	µg/L	NA	---	#DIV/0!	---	#DIV/0!	#DIV/0!	#DIV/0!
47	SDS-HAA5	µg/L	42.50	---	808.46	---	68.4	802.08	94.7
48	SDS-HAA6	µg/L	61.00	---	924.88	---	63.0	917.68	93.4
49	BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported								
50	*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.								
51									
52	**Exhibit 6-10 Example Of Field 10 For The RBSMT Data Sheet**								

Field E-13: Blending Calculations For Stage 1 D-DBP MCLs

Feed and Permeate Water Quality Parameters

EP	EQ	ER	ES	ET
	RUN ID #			
Parameter	**1**	**2**	**3**	**4**
SDS-$THM4_F$, ug/L	271.13	271.13	271.13	271.13
SDS-$THM4_p$, ug/L	72.54	107.05	48.76	37.74
SDS-$HAA5_F$, ug/L	134.42	134.42	134.42	134.42
SDS-$HAA5_p$, ug/L	26.26	42.50	18.85	14.73
SDS-TOX_F, ug Cl^- /L	1075.00	1075.00	1075.00	1075.00
SDS-TOX_p, ug Cl^- /L	77.50	170.00	50.00	35.00
SDS-CD_F, mg/L	12.05	12.05	12.05	12.05
SDS-CD_p, mg/L	1.50	3.50	1.00	0.70
TOC_F, mg/L	9.70	9.70	9.70	9.70
TOC_p, mg/L	1.95	3.60	1.20	0.90
$UV_{254\ F}$, cm^{-1}	0.331	0.331	0.331	0.331
$UV_{254\ p}$, cm^{-1}	0.028	0.050	0.018	0.012
$Bromide_F$, ug/L	251.5	251.5	251.5	251.5
$Bromide_p$, ug/L	151.5	200.0	120.0	100.0
Alk_F, mg/L $CaCO_3$	72.5	72.5	72.5	72.5
Alk_p, mg/L $CaCO_3$	15.0	28.0	10.0	7.0
T-Hd_F, mg/L $CaCO_3$	314.5	314.5	314.5	314.5
T-Hd_p, mg/L $CaCO_3$	31.0	70.0	23.0	16.0
Ca-Hd_F, mg/L $CaCO_3$	289.5	289.5	289.5	289.5
Ca-Hd_p, mg/L $CaCO_3$	28.5	52.0	18.0	13.0

Blended Water Quality if THM4 Controls the Blend Ratio

Q_p/Q_T (THM4), %	100.3	121.4	89.5	85.3
SDS-$THM4_b$, ug/L	NA	NA	72.00	72.00
SDS-$HAA5_b$, ug/L	NA	NA	30.93	32.30
SDS-TOX_b, ug Cl^- /L	NA	NA	157.12	187.66
SDS-CD_b, mg/L	NA	NA	2.15	2.37
TOC_b, mg/L	NA	NA	2.09	2.19
$UV_{254\ b}$, cm^{-1}	NA	NA	0.051	0.059
$Bromide_b$, ug/L	NA	NA	133.7	122.2
Alk_b, mg/L $CaCO_3$	NA	NA	16.5	16.6
T-Hd_b, mg/L $CaCO_3$	NA	NA	53.5	59.8
Ca-Hd_b, mg/L $CaCO_3$	NA	NA	46.4	53.6

Blended Water Quality if HAA5 Controls the Blend Ratio

Q_p/Q_T (HAA5), %	74.4	87.5	69.6	67.2
SDS-$THM4_b$, ug/L	123.48	127.58	116.40	114.32
SDS-$HAA5_b$, ug/L	54.00	54.00	54.00	54.00
SDS-TOX_b, ug Cl^- /L	333.34	283.23	361.76	376.24
SDS-CD_b, mg/L	4.21	4.57	4.36	4.42
TOC_b, mg/L	3.94	4.36	3.79	3.79
$UV_{254\ b}$, cm^{-1}	0.106	0.085	0.113	0.117
$Bromide_b$, ug/L	177.1	206.4	160.0	149.7
Alk_b, mg/L $CaCO_3$	29.7	33.6	29.0	28.5
T-Hd_b, mg/L $CaCO_3$	103.7	100.6	111.7	113.9
Ca-Hd_b, mg/L $CaCO_3$	95.4	81.7	100.6	103.7

Notes:

This spreadsheet uses the feed and permeate water quality parameters copied to the first block to determine the percentage of total flow that must be treated by the membrane process to meet the Stage 1 DBP MCLs.

A 10% factor of safety has been applied all the MCLs. i.e., 72 / 54 µg/L for THM4 and HAA5.

Since either THM4 or HAA5 can control the allowable blend ratio, the blend ratio is calculated for both parameters and **the maximum (Q_p/Q_T) ratio controls the design**.

Q_p/Q_T (THM4) is the permeate to total flow ratio for the case where THM4 controls the blend ratio.

Q_p/Q_T (HAA5) is the permeate to total flow ratio for the case where HAA5 controls the blend ratio.

The subscript "b" refers to the blended water quality for a given blend ratio.

If the permeate quality does not meet the MCL, then the calculations are meaningless for that MCL.

If the feed water quality meets the MCL, then a negative ratio will be calculated for that MCL.

Exhibit 6-11 Example Of Field 13 For The RBSMT Data Sheet

	FB	FC
3	**Field E-15: Membrane Cost Parameters**	
4	***General Cost Parameters***	
5	**Cost Parameter**	**Parameter value**
6	Capital Recovery Interest Rate (%)	10
7	Capital Recovery Period (years)	20
8	Overhead & Profit Factor (% of construction costs)	5
9	Special Sitework Factor (% of construction costs)	5
10	Construction Contingencies (% of construction costs)	10
11	Engineering Fee Factor (% of construction costs)	10
12	1998 ENR Construction Cost Index (CCI base year 1913)	####
13	1998 Producers Price Index (PPI base year 1967 = 100)	###
14	Labor Rate + Fringe ($/work-hour)	15
15	Labor Overhead Factor (% of labor)	10
16	Electric Rate ($/kW-h)	0.086
17	Fuel Oil Rate ($/gal)	0.89
18	Natural Gas Rate (\$/ft^3)	0.0055
19	Current Process Water Rate ($/1000 gal)	0.35
20	Modifications to Existing Plant (% of construction costs)	5
21		
22	**Exhibit 6-12 Example Of Field 15 For The RBSMT Data Sheet**	

Appendix 6a: Membrane RBSMT Equations And Nomenclature

Nomenclature

$\mathbf{A_{cell}}$	Active area of membrane in the bench-scale cell **(ft^2)**
BCAA	Bromochloroacetic acid **(μg/L)**
BDCAA	Bromodichloroacetic acid **(μg/L)**
BDCM	Bromodichloromethane **(μg/L)**
BMRL	Below minimum reporting level
$\mathbf{C_b}$	Concentration of a blended sample (i.e., feed:permeate blend)
$\mathbf{C_B}$	Concentration in bulk solution
$\mathbf{C_C}$	Concentration in the concentrate stream (i.e., waste and recycle streams)
$\mathbf{C_{C(calc)}}$	Concentrate concentration based on a mass balance calculation
$\mathbf{C_F}$	Concentration in the feed stream
$\mathbf{C_p}$	Concentration in the permeate stream
$\mathbf{C_{TG}}$	Treatment goal concentration (e.g., 72μg/L of THM4 for 90% Stage 1 MCL)
CHBr3	Bromoform **(μg/L)**
CHCl3	Chloroform **(μg/L)**
DBAA	Dibromoacetic acid **(μg/L)**
DBCAA	Dibromochloroacetic acid **(μg/L)**
DBCM	Dibromochloromethane **(μg/L)**
DCAA	Dichloroacetic acid **(μg/L)**
$\mathbf{Error_{MB}}$	Mass balance closure error **(%)**
$\mathbf{F_{\mathit{W}\text{-design}}}$	Design permeate water flux **(gfd)**
$\mathbf{F_{\mathit{W}}(T^\circ C)}$	Water flux at ambient temperature, T°C, **(gfd)**
$\mathbf{F_{\mathit{W}}(Tavg^\circ C)}$	Water flux at the average yearly water temperature, Tavg°C, **(gfd)**
LSI	Langelier saturation index
MBAA	Monobromoacetic acid **(μg/L)**
MCAA	Monochloroacetic acid **(μg/L)**
MFI	Modified fouling index
MPFI	Mini plugging factor index
$\mathbf{MTC_{\mathit{W}}}$	Water mass transfer coefficient **(gfd/psi)**
$\mathbf{MTC_{\mathit{W}}(Tavg^\circ C)}$	Water mass transfer coefficient at average temperature, Tavg°C, **(gfd/psi)**
NA	Not analyzed
NDP	Net driving pressure **(psi)**
NR	Not reported
$\mathbf{P_C}$	Pressure of the concentrate stream **(psi)**
$\mathbf{P_I}$	Pressure of the influent stream **(psi)**
$\mathbf{Q_F}$	Feed flow rate **(mL/min)**
$\mathbf{Q_{I\text{-}cell}}$	Influent flow rate to the RBSMT bench-scale cell **(mL/min)**
$\mathbf{Q_{I\text{-}element}}$	Influent flow rate to an 8" x 40" spiral-wound element **(gpm)**
$\mathbf{Q_p}$	Permeate flow rate **(mL/min)**
$\mathbf{Q_R}$	Concentrate-recycle flow rate **(mL/min)**
$\mathbf{Q_T}$	Total product flow (i.e., permeate flow plus by-passed feed flow) **(mL/min)**
$\mathbf{Q_W}$	Concentrate-waste flow rate **(mL/min)**

r	Recycle ratio
r_b	Permeate:total product flow blend ratio (i.e., **Q_p/Q_T**)
R	Recovery **(decimal fraction)**
R_B	Rejection based on the bulk concentration **(%)**
R_F	Rejection based on the feed concentration **(%)**
Rej_{TDS}	Manufacturer report rejection of TDS **(decimal fraction)**
SDI	Silt density index
SDS	Simulated distribution system
SDS-CD	SDS chlorine demand **(mg/L)**
SDS-Cl Dose	SDS chlorine dose **(mg/L)**
SDS-CR	SDS free chlorine residual **(mg/L)**
SDS-HAA5	The sum of five haloacetic acids evaluated under SDS conditions **(µg/L)**
SDS-HAA6	The sum of six haloacetic acids evaluated under SDS conditions **(µg/L)**
SDS-THM4	The sum of four trihalomethanes evaluated under SDS conditions **(µg/L)**
SDS-TOX	Total organic halides evaluated under SDS conditions **(µg Cl^-/L)**
SUVA	Specific ultraviolet absorbance **(L/(mg*m))**
T	Thickness of the mesh feed spacer used in the cell and full-scale element **(ft)**
T°C	Ambient temperature **(°C)**
Tavg°C	Average yearly water temperature at the plant **(°C)**
TBAA	Tribromoacetic acid **(µg/L)**
TCAA	Trichloroacetic acid **(µg/L)**
TDS_F	Total dissolved solids in the feed stream **(mg/L)**
TDS_I	Total dissolved solids in the influent stream **(mg/L)**
TDS_p	Total dissolved solids in the permeate stream **(mg/L)**
TDS_W	Total dissolved solids in the concentrate-waste stream **(mg/L)**
TOC	Total organic carbon **(mg/L)**
UV_{254}	Ultra-violet absorbance at 254 nm **(cm^{-1})**
v_c	Cross-flow velocity **(fps)**
w_{cell}	Active width of membrane in the bench-scale cell **(ft)**
$w_{element}$	Total width of all membrane envelopes in an 8" x 40" full-scale element **(ft)**
$\Delta\pi$	Osmotic pressure gradient **(psi)**

RBSMT Design Calculations

Temperature Normalized MTC_W (Example cell: M10)

$$\mathbf{MTC_{\mathit{W}}(Tavg^\circ C) = MTC_{\mathit{W}}(T^\circ C) \times 1.03^{(Tavg^\circ C - T^\circ C)}} \quad \textbf{(6a.1)}$$

Osmotic Pressure Estimate For Design Calculations (Example cells: J15:J18)

$$\Delta\pi = \mathbf{0.01 \times TDS_F \times (1 - R \times (1 - Rej_{TDS})) / (1 - R)} \quad \textbf{(6a.2)}$$

Design Influent Pressure (Example cells: K15:K18)

$$\mathbf{P_I = (F_{\mathit{W}\text{-design}} / MTC_{\mathit{W}}(Tavg^\circ C)) + \Delta\pi} \quad \textbf{(6a.3)}$$

Minimum Influent Flow Rate To RBSMT Cell (Example cells: L15:L18)

$$\mathbf{Q_{I\text{-}cell} = Q_{I\text{-}element} \times (w_{cell}/w_{element}) \times 3785\ (mL/gal)} \quad \textbf{(6a.4)}$$

Permeate Flow Rate (Example cells: M15:M18)

$$\mathbf{Q_p = F_{\mathit{W}} \times A_{cell} \times 2.628\ ((mL/min) / (gpd))} \quad \textbf{(6a.5)}$$

Feed Flow Rate (Example cells: N15:N18)

$$\mathbf{Q_F = Q_p / R} \quad \textbf{(6a.6)}$$

Concentrate-Waste Flow Rate (Example cells: O15:O18)

$$\mathbf{Q_W = Q_F - Q_p} \quad \textbf{(6a.7)}$$

Membrane Operating Parameters and Productivity

Feed Flow Rate (Example cells: AN9:AN41, BK9:BK46)

$$\mathbf{Q_F = Q_p + Q_W} \quad \textbf{(6a.8)}$$

Cross-Flow Velocity (Example cells: AO9:AO41, BL9:BL46)

$$\mathbf{v_c = (Q_{I\text{-}cell} / (w_{cell} \times T)) \times 5.886 \times 10^{-7}\ (cfs\ per\ mL/min)} \quad \textbf{(6a.9)}$$

System Recovery (Example cells: AP9:AP41, BM9:BM46)

$$\mathbf{R = Q_p / Q_F} \quad \textbf{(6a.10)}$$

Recycle Ratio (Example cells: AQ9:AQ41, BN9:BN46)

$$\mathbf{r = Q_R / Q_F} \quad \textbf{(6a.11)}$$

Water Flux at Ambient Temperature (Example cells: AR9:AR41, BO9:BO46)

$$\mathbf{F_{\mathit{W}}(T^\circ C) = (Q_p / A_{cell}) \times 0.3804\ (gpd\ per\ mL/min)} \quad \textbf{(6a.12)}$$

Water Flux at Average Water Temperature (Example cells: AS9:AS41, BP9:BP46)

$$\mathbf{F_{\mathit{W}}(Tavg^\circ C) = F_{\mathit{W}}(T^\circ C) \times 1.03^{(Tavg^\circ C - T^\circ C)}} \quad \textbf{(6a.13)}$$

Estimate of Osmotic Pressure Gradient (Example cells: AW9:AW41, BT9:BT46)

$$\mathbf{\Delta\pi = 0.01 \times (((TDS_I + TDS_W) / 2) - TDS_p)} \quad \textbf{(6a.14)}$$

Net Driving Pressure (Example cells: AX9:AX41, BU9:BU46)

$$\mathbf{NDP = ((P_I + P_C) / 2) - \Delta\pi} \qquad \textbf{(6a.15)}$$

MTC_W at Average Temperature (Example cells: AY9:AY41, BV9:BV46)

$$\mathbf{MTC_{\mathit{W}}(Tavg°C) = F_{\mathit{W}}(Tavg°C) / NDP} \qquad \textbf{(6a.16)}$$

<u>Estimate of Concentrate-Waste, Permeate and Influent TDS Concentrations</u>

Estimate of Concentrate-Waste TDS Concentration (Example cells: AT9:AT41, BQ9:BQ46)

$$\mathbf{TDS_W = TDS_F \times (1 + r - R + (R \times Rej_{TDS}))/(1 + r - R - (r \times R \times Rej_{TDS}))} \qquad \textbf{(6a.17)}$$

Estimate of Permeate TDS Concentration (Example cells: AU9:AU41, BR9:BR46)

$$\mathbf{TDS_p = (Q_F \times TDS_F - Q_W \times TDS_W)/Q_p} \qquad \textbf{(6a.18)}$$

Estimate of Influent TDS Concentration (Example cells: AV9:AV41, BS9:BS46)

$$\mathbf{TDS_I = (Q_F \times TDS_F + r \times Q_F \times TDS_W) / Q_I} \qquad \textbf{(6a.19)}$$

<u>Water Quality Analysis</u>

SDS-Chlorine Demand (Example cells: Z23, AA23, DA28, DB28, DN28, DX28, EH28)

$$\mathbf{(SDS\text{-}CD) = (SDS\text{-}Cl\ Dose) - (SDS\text{-}CR)} \qquad \textbf{(6a.20)}$$

SDS-HAA5 (Example cells: Z42, AA42, DA47, DB47, DN47, DX47, EH47)

$$\mathbf{SDS\text{-}HAA5 = MCAA + DCAA + TCAA + MBAA + DBAA} \qquad \textbf{(6a.21)}$$

SDS-HAA6 (Example cells: Z43, AA43, DA48, DB48, DN48, DX48, EH48)

$$\mathbf{SDS\text{-}HAA6 = MCAA + DCAA + TCAA + MBAA + DBAA + BCAA} \qquad \textbf{(6a.22)}$$

SDS-THM4 (Example cells: Z32, AA32, DA37, DB37, DN37, DX37, EH37)

$$\mathbf{SDS\text{-}THM4 = CHCl3 + BDCM + DBCM + CHBr3} \qquad \textbf{(6a.23)}$$

Calculated Concentrate Concentration (Example cells: CC9:CC46, CK9:CK46, CS9:CS46, DF16:DF48, DP16:DP48, DZ16:DZ48, EJ16:EJ48)

$$\mathbf{C_{C(calc)} = (C_F - R \times C_p) / (1\text{-}R)} \qquad \textbf{(6a.24)}$$

Mass Balance Closure Error (Example cells: CD9:CD46, CL9:CL46, CT9:CT46, DG16:DG23, DQ16:DQ23, EA16:EA23, EK16:EK23)

$$\mathbf{Error_{MB} = ((C_C - C_{C(calc)}) / C_C) \times 100\%} \qquad \textbf{(6a.25)}$$

Feed Rejection (Example cells: CE9:CE46, CM9:CM46, CU9:CU46, DH16:DH48, DR16:DR48, EB16:EB48, EL16:EL48)

$$\mathbf{R_F = ((C_F - C_p)/C_F) \times 100\%} \qquad \textbf{(6a.26)}$$

Bulk Concentration (Example cells: CF9:CF46, CN9:CN46, CV9:CV46, DI16:DI48, DS16:DS48, EC16:EC48, EM16:EM48)

$$\mathbf{C_B = (C_F \times Q_F + C_C \times (2 \times Q_I - Q_F))/2 \times Q_I} \qquad \textbf{(6a.27)}$$

Bulk Rejection (Example cells: CG9:CG46, CO9:CO46, CW9:CW46, DJ16:DJ48, DT16:DT48, ED16:ED48, EN16:EN48)

$$\mathbf{R_B = ((C_B - C_p)/C_B)\times 100\%} \tag{6a.28}$$

Blend Ratio (Example cells: EQ29:ET29, EQ43:ET43, EW29:EZ29, EW43:EZ43)

$$\mathbf{r_b = Q_p/Q_T = (C_F - C_{TG})/(C_F - C_p)} \tag{6a.29}$$

C_{TG}(THM4, Stage 1) = 72 μg/L; C_{TG}(HAA5, Stage 1) = 54 μg/L;
C_{TG}(THM4, Stage 2) = 36 μg/L; C_{TG}(HAA5, Stage 2) = 27 μg/L

Blended Water Quality (Example cells: EQ30:ET39, EQ44:ET53, EW30:EZ39, EW44:EZ53)

$$\mathbf{C_b = r_b\times(C_p - C_F) + C_F} \tag{6a.30}$$

SUVA (Example cells: Z19:AA19, DA24:DB24, DE24, DN24:DO24, DX24:DY24, EH24:EI24)

$$\mathbf{SUVA = (UV_{245}/TOC)\times 100(cm/m)} \tag{6a.31}$$

7.0 Spreadsheets For Membrane SEBST Bench-Scale Studies

The SEBST spreadsheets are included in two files, and each file is designed to contain all of the data from four quarterly SEBST studies evaluating *one* membrane. As summarized in Table 7-1, files *sebst-1.xls* and *sebst-2.xls* are used to report the results from the evaluation of the first and second membranes, respectively.

File name	Description
sebst-1.xls	SEBST spreadsheet file used to report results for 1st membrane
sebst-2.xls	SEBST spreadsheet file used to report results for 2nd membrane

Table 7-1 Summary Of SEBST Spreadsheet Files

File *sebst-1.xls* contains five (5) field-sets, while *sebst-2.xls* contains four (4) field-sets. Each field-set is located on a separate worksheet, and Table 7-2 summarizes the designation, sheet title and cell range for each field-set. Each field-set is designed to contain the data from *one* quarterly SEBST study evaluating *one* membrane. The extra field-set in *sebst-1.xls* is an Example Field-Set which demonstrates the use of the SEBST spreadsheets. Example data are presented in each field to clarify the use of these spreadsheets and to verify that the spreadsheet equations are functioning properly. Field-Sets 1 through 4 are used to report the results from the four quarterly SEBST studies.

Field-Set Title (Designation)	Sheet Title	Field-Set Cell Range
Example SEBST Data (E-)	Sheet0. Example Data	A1:DR76
1st Quarter SEBST Results (1-)	Sheet1. 1st Quarter	A1:DR119
2nd Quarter SEBST Results (2-)	Sheet2. 2nd Quarter	A1:DR119
3rd Quarter SEBST Results (3-)	Sheet3. 3rd Quarter	A1:DR119
4th Quarter SEBST Results (4-)	Sheet4. 4th Quarter	A1:DR119

Table 7-2 Summary Of SEBST Field-Sets And Corresponding Sheet Titles

Each field-set contains twelve (12) fields which are identified by the field-set designation (i.e., E, 1, 2, 3 or 4) followed by a field designation (i.e., 1 through 12). For example, Field 1-6 is the sixth field in Field-Set 1, and Field 4-6 is the sixth field in Field-Set 4. Furthermore, fields with the same *field designation* are identical (e.g., Field 1-6 is the same as Field 4-6 except that Field 1-6 is used to report the first set of quarterly results, and Field 4-6 is used to report the fourth set of quarterly results). The field titles, designations and cell ranges are summarized in Table 7-3, and the individual fields are described in Sections 7.1 through 7.12.

Field Title	Designation	Field Cell Range
PWS and Treatment Plant Data	1	A3:B30
Manufacturer Reported Membrane Characteristics	2	D3:E45
SEBST Design Parameters	3	G3:H35
Foulants and Fouling Indices	4	J3:K29
Pretreatment Used Prior to Membranes	5	M3:O24
Membrane Performance Data During Operation With The Test Water	6	Q3:BL119
Permeate, Feed, Concentrate And Blended Water Quality For Week 1	7	BN3:BW76
Permeate, Feed, Concentrate And Blended Water Quality For Week 2	8	BY3:CH76
Permeate, Feed, Concentrate And Blended Water Quality For Week 3	9	CJ3:CS76
Permeate, Feed, Concentrate And Blended Water Quality For Week 4	10	CU3:DD76
Duplicate Analysis Of Permeate, Feed, Concentrate And Blended Water Quality For Week ___	11	DF3:DO76
Membrane Cost Parameters	12	DQ3:DR20

Table 7-3 Summary Of SEBST Data Fields

7.1 Field 1: PWS And Treatment Plant Data *(A3:B30)*

Exhibit 7-1 presents an example of Field 1 which is used to enter the Public Water System (PWS) and treatment plant data, including the PWSID#, plant ICR #, and addresses and phone numbers of the official and technical ICR contacts. Some of the information in Field 1 is optional (i.e., the WIDB number and e-mail addresses).

7.2 Field 2: Manufacturer Reported Membrane Characteristics *(D3:E45)*

Exhibit 7-2 presents an example of Field 2 which is used to enter the manufacturer reported characteristics of the membrane used in the SEBST study. The first block of cells in Field 2, ***General Information (D4:E12)***, is used to enter information including the membrane manufacturer, trade name, membrane element model number, molecular weight cutoff, etc. The second block, ***Design Parameters (D14:E26)***, is used to enter values for the parameters that will be used in the design of the SEBST study, and all of the information in this block **must** be entered including:

- The size of the element used during the study, such as a 2.5" by 40" element or a 4" by

40" element. (The minimum element size that can be used is a 2.5" x 40".)

- The active membrane area of the element used (A) in **ft^2**.
- The design flux (F_W) in **gfd**.
- The net driving pressure (NDP) at this design flux in **psi**.
- The water mass transfer coefficient, or water flux per unit of net driving pressure (MTC_W) in **gfd/psi**. (If the MTC_W is not explicitly reported by the manufacturer, it can be calculated by dividing the design flux by the net driving pressure at this design flux.)
- The temperature (T°C) at which the design flux or MTC_W was measured in **°C**.
- The maximum ($Q_{I, max}$) and minimum ($Q_{I, min}$) allowable flow rates to the element used in the study in **gpm**.
- The total width of all membrane envelopes in the element used in the study (w) in **ft** (i.e., this is the *width* of the feed flow channel in the membrane element).
- The thickness of the feed spacer in the element used in the study (T) in **ft** (i.e., this is the *thickness* of the feed flow channel in the membrane element).
- The active membrane area of an equivalent 8" x 40" membrane element in **ft^2**.
- The purchase price of an equivalent 8" x 40" membrane element in **$**.

The third block in this field ***(D28:E43)*** is used to enter additional information reported by the manufacturer such as the required feed flow to permeate flow rate ratio, the maximum element recovery, and other information that could be used during the design of the SEBST study.

7.3 Field 3: SEBST Design Parameters *(G3:H35)*

Exhibit 7-3 presents an example of Field 3 which uses information entered in Field 2, as well as design parameters entered in Field 3, to calculate the operating parameters for the SEBST studies.

In the first block of this field, ***Calculate Temperature Normalized MTC_W (G4:H6)***, the user must enter the average yearly water temperature of the feed water at the plant in **°C**, and the spreadsheet will calculated the MTC_W normalized to this average yearly water temperature. In the second block, ***Calculate System Flow Rates (G8:H22)***, the user must enter the design recovery as a decimal fraction (i.e., this should be 0.75 according to the requirements in the *ICR Manual for Bench- and Pilot- Scale Treatment Studies*). The spreadsheet calculates the following flow rates in gallons per minute:

- The permeate flow rate (Q_p) in **gpm**.
- The feed flow rate (Q_F) in **gpm**.
- The concentrate-waste flow rate (Q_W) in **gpm**.
- The minimum required influent flow rate to the element ($Q_{I, min}$) in **gpm**.
- The maximum allowable influent flow rate to the element ($Q_{I, max}$) in **gpm**.

The user must then enter the design influent flow rate (Q_I), which must be in the range established by the minimum and maximum influent flow rates. The spreadsheet will then use this information to calculate the required recycle flow rate (Q_R) and recycle ratio (r).

In the third block of this field, ***Estimate the Osmotic Pressure Gradient (G24:H30)***, the user must enter the TDS rejection (Rej_{TDS}) of the membrane being investigated along with the approximate TDS concentration of the feed to the membrane system (TDS_F). The TDS rejection can either be obtained from the manufacturer or measured directly, but the TDS rejection should be evaluated at a low recovery (i.e., < 30%) to approximate the bulk rejection. The spreadsheet uses the entered TDS rejection and feed TDS concentration to calculate the waste, permeate and influent TDS concentrations which are used to estimate the osmotic pressure gradient ($\Delta\pi$).

The fourth block of this field, ***Estimate the Required Influent Pressure (G32:H35)***, requires that the user enter an estimate of the system pressure losses (ΔP_{loss}) and the desired permeate stream pressure (P_p). The spreadsheet will then calculate the required influent pressure (P_I) based on the osmotic pressure gradient, the design flux, the water mass transfer coefficient, the estimated system pressure losses and the design permeate pressure.

The flow rates and pressures calculated in this field are intended to provide a starting point for the SEBST study, and the concentrate-waste flow rate and influent pressure may need to be adjusted during the course of the run to obtain the desired recovery and permeate flux.

7.4 Field 4: Foulants And Fouling Indices *(J3:K29)*

Exhibit 7-4 shows an example of Field 4 which is used to report the concentrations of various foulants and the values of fouling indices for the feed water prior to pretreatment. Numerous water quality parameters that could constitute a fouling problem are included here, however only those parameters relevant to the water being tested need to be evaluated. Foulants and indices not listed in this field, but which are evaluated as part of the study, should be reported in the blank rows. The information in this field should be used to select appropriate pretreatment to membrane separations in order to minimize fouling.

7.5 Field 5: Pretreatment Used Prior To Membranes *(M3:O24)*

Field 5 is used to report all pretreatment processes used prior to the SEBST test system, and Exhibit 7-5 presents an example of Field 5. All full-scale and pilot-scale pretreatment processes should be listed in this field. The process name should be entered, along with a brief description of the process (e.g., chemical dose, cartridge filter exclusion size, etc.) and the scale of the process (i.e., full-scale or pilot-scale). Detailed design information is not required in this spreadsheet since this design data will be included in the hard-copy *Treatment Study Summary Report* as described in Section 10.0 of this document. The purpose of Field 5 is to associate the pretreatment processes used during the SEBST study with the data entered in the spreadsheet.

7.6 Field 6: Membrane Performance Data During Operation With The Test Water *(Q3:BL119)*

Field 6 is used to report the parameters monitored during operation with the pretreated test water, and an example of Field 6 is shown in Exhibit 7-6. In this field, the date, time and cumulative operation time must be reported. The operation time is reported in decimal hours and is defined with respect to the starting date and time of SEBST operation with the pretreated test water. Any period of time during which system operation is interrupted (e.g., during a cleaning event) must not be included in the cumulative operation time. Membrane cleaning events should be indicated with an "**X**" in column ***AA*** of this field.

The operating parameters that are reported in Field 6 include the influent temperature and pressure; the concentrate and permeate pressures; and the permeate, concentrate-recycle and concentrate-waste flow rates. The spreadsheet uses these entered values to calculate operating parameters such as the feed flow rate, influent flow rate, cross-flow velocity, recovery, flux, net driving pressure and water mass transfer coefficient. **It is important to enter all measured parameters in the specified units: temperature in °C, pressure in psi and flow rate in gpm.**

The temperature normalized flux is calculated using a generic temperature correction equation (see Equation 7a.18 in Appendix 7a). If a membrane specific temperature correction equation is provided by the manufacturer, it should be used instead of Equation 7a.18. To use a different temperature correction equation, overwrite the existing equation in cells ***AH7:AH119***, making sure that the revised equation references the proper cells. To overwrite an equation in the spreadsheet, the sheet must be Unprotected, and the cells containing the equation must be unLocked as described in Section 3.3.

Field 6 is also used to report the feed, permeate and concentrate water quality parameters that are monitored with time: pH and TDS (and UV_{254} / TOC if measured). The TDS and pH must be monitored every time the system flows and pressures are monitored; however, UV_{254} and/or TOC can be monitored at any desired frequency, if at all. For measured parameters, the spreadsheet will calculate the feed rejection (R_F), the calculated concentrate concentration ($C_{C(calc)}$), the bulk concentration (C_B) and the bulk rejection (R_B). When both permeate and concentrate water quality parameters are analyzed during the same sampling event, the mass balance closure error ($Error_{MB}$) is calculated.

7.7 Field 7: Permeate, Feed, Concentrate And Blended Water Quality For Week 1 *(BN3:BW76)*

Field 7 is used to report the permeate, feed and concentrate water quality for the first week of SEBST operation, and an example of Field 7 is shown in Exhibit 7-7. The date, time and operation time at which each sample was collected must be entered in Field 7. The following water quality parameters must be analyzed and reported for the permeate and feed samples: pH, temperature, alkalinity, TDS, total hardness, calcium hardness, turbidity, ammonia, TOC, UV_{254}, bromide, SDS-chlorine demand, SDS-TOX, SDS-THM4 and SDS-HAA6[1].

The following concentrate water quality parameters must be reported in Field 7: pH, temperature, alkalinity, TDS, total hardness, calcium hardness, turbidity, ammonia, TOC and UV_{254}. The spreadsheet will automatically calculate the mass balance closure error for these water quality parameters with the exception of pH and temperature.

The spreadsheet also calculates the concentrate concentration, the feed rejection, the bulk

[1]Only six HAA species are required, but the additional three HAA species (TBAA, CDBAA and DCBAA) should be reported if measured.

concentration and the bulk rejection, as well as the SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

In order to calculate the mass balance closure error, bulk concentration and bulk rejection, the following operating parameters must be entered in cells ***BP5:BP7*** of Field 7: the recovery, feed flow rate and influent flow rate. These operating parameters must reflect operation of the system during the time at which the permeate and concentrate samples were collected. The recovery must be expressed as a decimal fraction and the flow rates must be expressed in gpm.

The third block of Field 7, ***Blending Calculation for D-DBP MCLs (BN52:BT76)***, calculates the permeate flow to total product flow ratio (i.e., blend ratio) that can be used to meet the Stage 1 and proposed Stage 2 D-DBP MCLs with a 10% factor of safety. The spreadsheet uses the permeate and feed concentrations entered in the second block of Field 7 ***(BN9:BW50)*** to calculate the permeate to total product flow ratio (Q_p/Q_T) required to achieve the D-DBP MCLs with a 10% factor of safety. For Stage 1, 90% of the D-DBP MCLs are 72 μg/L for THM4 and 54 μg/L for HAA5. For Stage 2, 90% of the D-DBP MCLs are 36 μg/L for THM4 and 27 μg/L for HAA5. The blend ratio is used to calculate the water quality of the feed/permeate blend. Blended water qualities are indicated by the subscript "b" and are calculated for SDS-THM4, SDS-HAA5, SDS-TOX, SDS-CD, TOC, UV_{254}, bromide, alkalinity, total hardness and calcium hardness.

In some cases, the blending calculations are meaningless. If the permeate concentration does not meet 90% of the DBP MCL prior to blending, then the blend ratio will be greater than 100% indicating that blending is not feasible. If the feed concentration meets 90% of the DBP MCL prior to blending then nanofiltration is not required to meet the MCL and the blend ratio will be negative. In both of these cases, the spreadsheet will report "NA" for the blended water quality parameters since the calculated values have no physical significance.

When the blending calculations are relevant, the user must compare the blend ratios calculated for THM4 and HAA5 since the higher blend ratio is the minimum ratio that will meet both MCLs with a 10% factor of safety. For example, in Exhibit 7-7 the THM4 MCL controls the blend ratio for both Stage 1 and Stage 2.

7.8 Field 8: Permeate, Feed, Concentrate And Blended Water Quality For Week 2 *(BY3:CH76)*

Field 8 is identical to Field 7 except that it is used to report the permeate, feed and concentrate water quality for the second week of SEBST operation.

7.9 Field 9: Permeate, Feed, Concentrate And Blended Water Quality For Week 3 *(CJ3:CS76)*

Field 9 is identical to Field 7 except that it is used to report the permeate, feed and concentrate water quality for the third week of SEBST operation.

7.10 Field 10: Permeate, Feed, Concentrate And Blended Water Quality For Week 4 *(CU3:DD76)*

Field 10 is identical to Field 7 except that it is used to report the permeate, feed and concentrate water quality for the fourth week of SEBST operation.

7.11 Field 11: Duplicate Analysis Of Permeate, Feed, Concentrate And Blended Water Quality For Week ___ *(DF3:DO76)*

As shown in Exhibit 7-8, Field 11 is identical to Field 7 with the exception that Field 11 is used to report the results from duplicate analysis performed on one set of weekly permeate, feed and concentrate samples. The duplicate analyses can be performed on any set of weekly SEBST samples.

7.12 Field 12: Membrane Cost Parameters *(DQ3:DR20)*

Field 12 is used to report the utility-specific cost parameters that are used to generate cost estimates for the use of membrane technology, and an example of Field 12 is shown in Exhibit 7-9. Example cost parameters are listed in Exhibit 7-9, but it is important to report cost parameters specific to the utility and not default or example values.

	A	B
3	**Field E-1: PWS And Treatment Plant Data**	
4		
5	PWS Name	Anytown Public Works
6	Public Water System Identification Number	OH1234567
7	Water Industry Data Base Number (*optional*)	######
8		
9	Official ICR Contact Person	Mr. Any Body
10	Mailing Address	#### Street
11		City, State Zip code
12	Phone Number	(###) ###-####
13	FAX Number	(###) ###-####
14	E-Mail Address (*optional*)	last.first@wtp.com
15		
16	Technical ICR Contact Person	Ms. Some One
17	Mailing Address	#### Street
18		City, State Zip code
19	Phone Number	(###) ###-####
20	FAX Number	(###) ###-####
21	E-Mail Address (*optional*)	last.first@wtp.com
22		
23	Plant Name	East WTP
24	Treatment Plant Category	CONV
25	Process Train Name	Conventional train
26	ICR Treatment Plant Identification Number	###
27	PWSID Number of Plant (*if assigned*)	Not assigned
28	Historical Minimum Water Temperature (^{o}C)	4.0
29	Historical Average Water Temperature (^{o}C)	18.0
30	State Approved Plant Capacity (MGD)	100.0
31		
32	**Exhibit 7-1 Example Of Field 1 For The SEBST Data Sheet**	

	D	E
3	**Field E-2: Manufacturer Reported Membrane Characteristics[1]**	
4	***General Information***	
5	Membrane manufacturer	Company Name
6	Membrane trade name	NFPA-200
7	Membrane element model number	NFPA-200 4040
8	Molecular weight cutoff (Daltons)	200
9	Membrane material (e.g., PVD, polyamide, etc.)	polyamide
10	Membrane construction (e.g., thin-film composite)	thin-film composite
11	Membrane hydrophobicity	hydrophilic
12	Membrane charge (e.g., negative, highly negative, neutral, etc.)	highly negatively charged
13		
14	***Design Parameters***	
15	Element size (e.g., 2.5" x 40", 4" x 40", etc.)	4" x 40"
16	Active membrane area of membrane element used, A (ft^2)	70.0
17	Design flux, F_W (gfd)	15.0
18	Net driving pressure at the design flux, NDP (psi)	80.0
19	Water mass transfer coefficient, MTC_W (gfd/psi)	0.188
20	Temperature at which the MTC_W was determined, T^oC (^oC)	25.0
21	Maximum flow rate to the element, $Q_{I, max}$ (gpm)	16.0
22	Minimum flow rate to the element, $Q_{I, min}$ (gpm)	4.0
23	Total width of all membrane envelopes in the element, w (ft)	12.0
24	Feed spacer thickness, T (ft)	0.0025
25	Active membrane area of an equivalent 8" x 40" element (ft^2)	315.0
26	Purchase price for an equivalent 8" x 40 " element ($)	1000.00
27		
28	***Additional Information***	
29	Design cross-flow velocity (fps)	0.257
30	Required influent flow to permeate flow rate ratio, Q_I:Q_p	6:1
31	Maximum element recovery (%)	16
32	Variability of design flux (%)	15
33	Rejection of reference solute and conditions of test	90% rejection of a 2000 mg/L
34	(e.g., solute type and concentration)	$MgSO_4$ solution
35	Variability of rejection of reference solute (%)	1
36	Standard testing recovery (%)	15
37	Standard testing pH	7
38	Acceptable range of operating pressures	0 - 250
39	Acceptable range of operating pH values	3 - 9
40	Typical pressure drop across a single element (psi)	5
41	Maximum permissible SDI	5
42	Maximum permissible turbidity (ntu)	Not reported
43	Chlorine/oxidant tolerance (e.g., < 0.1 mg/L for extended use, etc.)	1.0 mg/L maximum
44	1: All of the information requested in this field may not be available, but values for all of the ***Design***	
45	***Parameters*** must be entered in cells E15:E26, since these parameters are used in calculations.	
46		
47	**Exhibit 7-2 Example Of Field 2 For The SEBST Data Sheet**	

	G	H
3	**Field E-3: SEBST Design Parameters**	
4	***Calculate Temperature Normalized MTC_W***	
5	Average yearly temperature of feed water, Tavg°C (°C)	18.0
6	Temperature normalized MTC_W, MTC_W(Tavg°C) (gfd/psi)	0.152
7		
8	***Calculate System Flow Rates*** [1]	
9	Design recovery, R (decimal)	0.75
10	Design flux, F_W (gfd)	15.0
11	Permeate flow rate, Q_p (gpm)	0.73
12	Feed flow rate, Q_F (gpm)	0.97
13	Concentrate-waste flow rate, Q_W (gpm)	0.24
14	Minimum influent flow rate, $Q_{I, min}$ (gpm)	4.0
15	Maximum influent flow rate, $Q_{I, max}$ (gpm)	16.0
16	Design influent flow rate[2], Q_I (gpm)	6.0
17	Design recycle flow rate, Q_R (gpm)	5.03
18	Recycle ratio, r	5.17
19	1: Flow rates and pressures may need to be adjusted in order to obtain	
20	the desired operating conditions.	
21	2: The design influent flow rate must be within the range established by the	
22	minimum and maximum influent flow rates (i.e., cells H14 and H15).	
23		
24	***Estimate the Osmotic Pressure Gradient***	
25	Manufacturer reported TDS rejection, Rej_{TDS} (decimal)	0.70
26	Feed TDS, TDS_F (mg/L)	150.0
27	Waste TDS, TDS_W (mg/L)	329.6
28	Permeate TDS, TDS_p (mg/L)	90.1
29	Influent TDS, TDS_I (mg/L)	300.5
30	Osmotic pressure gradient, $\Delta\pi$ (psi)	2.2
31		
32	***Estimate the Required Influent Pressure***	
33	Estimated system pressure losses, ΔP_{loss} (psi)	8.0
34	Design permeate pressure, P_p (psi)	4.0
35	Required influent pressure, P_I (psi)	112.6
36		
37	**Exhibit 7-3 Example Of Field 3 For The SEBST Data Sheet**	

	J	K
3	**Field E-4: Foulants And Fouling Indices**[1]	
4	***Parameters Evaluated Prior to Pretreatment***	
5	Alkalinity (mg/L as $CaCO_3$)	40
6	Calcium Hardness (mg/L as $CaCO_3$)	79
7	LSI	1.4
8	Dissolved iron (mg/L)	15
9	Total iron (mg/L)	17
10	Dissolved aluminum (mg/L)	
11	Total aluminum (mg/L)	
12	Fluoride (mg/L)	
13	Phosphate (mg/L)	
14	Sulfate (mg/L)	
15	Calcium (mg/L)	
16	Barium (mg/L)	
17	Strontium (mg/L)	
18	Reactive silica (mg/L as SiO_2)	
19	Turbidity (ntu)	5
20	SDI	4
21	MFI	
22	MPFI	
23		
24		
25		
26		
27		
28	1: Only those foulants and fouling indices relevant to the water being tested need to	
29	be evaluated. Additional foulants and indices can be listed in the blank rows.	
30		
31	**Exhibit 7-4 Example Of Field 4 For The SEBST Data Sheet**	

	M	N	O
3	**Field E-5: Pretreatment Used Prior To Membranes**[1]		
4			
5	**Process**	**Description**	**Scale**
6	Coagulation	50 ± 15 mg/L alum	Full-scale
7	Flocculation	2-stage	Full-scale
8	Sedimentation	tube settler	Full-scale
9	Dual media filtration	sand / anthracite	Full-scale
10	Cartridge filtration	2 µm exclusion size	Pilot-scale
11	Sulfuric acid addition	pH = 6.0	Pilot-scale
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22	1: Design information, similar to that shown in Tables 6c and 6d of the ICR rule, must be included in		
23	the hard-copy *Treatment Study Summary Report* (see Section 10.0). The purpose of this table		
24	is to list the pretreatment processes used in this particular SEBST run.		
25			
26	**Exhibit 7-5 Example Of Field 5 For The SEBST Data Sheet**		

Field E-6: Membrane Performance Data During Operation With The Test Water

	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
5	Date	Time	Operation time	Influent	P_I	P_C	P_P	Q_R	Q_p	Q_W	Cleaning Event	Q_F	Q_I	v_c	Recovery	Recycle	F_W (T°C)	F_W (Tavg°C)	$\Delta\pi$	NDP	MTC_W (Tavg°C)
6	MM/DD/YY	hh:mm	hh.hh	Temp. (°C)	(psi)	(psi)	(psi)	(gpm)	(gpm)	(gpm)	Indicate with "X"	(gpm)	(gpm)	(fps)	(decimal)	ratio	(gfd)	(gfd)	(psi)	(psi)	(gfd/psi)
7	4/1/96	8:00	0.00	18.0	113.0	105.0	4.0	4.90	0.74	0.23		0.97	5.87	0.408	0.76	5.05	15.22	15.22	3.2	101.8	0.150
8	4/1/96	20:00	12.00	18.1	114.0	105.0	4.0	5.00	0.74	0.24		0.98	5.98	0.417	0.76	5.10	15.22	15.18	3.2	102.3	0.148
9	4/2/96	8:00	24.00	18.0	115.0	105.0	4.0	5.00	0.75	0.24		0.99	5.99	0.417	0.76	5.05	15.43	15.43	3.3	102.7	0.150
10	4/2/96	20:00	36.00	18.2	115.0	105.0	4.0	4.80	0.75	0.24		0.99	5.79	0.402	0.76	4.85	15.43	15.34	3.3	102.7	0.149
11	4/3/96	8:00	48.00	18.2	116.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.54	3.4	103.1	0.151
12	4/3/96	20:00	60.00	18.3	116.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.50	3.2	103.3	0.150
13	4/4/96	8:00	72.00	18.3	116.0	105.0	4.0	5.10	0.75	0.25		1.00	6.10	0.425	0.75	5.10	15.43	15.29	3.2	103.3	0.148
14	4/4/96	20:00	84.00	18.3	116.0	105.0	4.0	5.00	0.73	0.26		0.99	5.99	0.418	0.74	5.05	15.02	14.88	3.1	103.4	0.144
15	4/5/96	8:00	96.00	18.4	117.0	105.0	4.0	4.90	0.74	0.24		0.98	5.88	0.409	0.76	5.00	15.22	15.04	3.3	103.7	0.145
16	4/5/96	20:00	108.00	18.3	117.0	105.0	4.0	5.10	0.74	0.24		0.98	6.08	0.424	0.76	5.20	15.22	15.09	3.1	103.9	0.145
17	4/6/96	8:00	120.00	18.3	117.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.29	3.2	103.9	0.147
18	4/6/96	20:00	132.00	18.2	117.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.34	3.0	104.0	0.147
19	4/7/96	8:00	144.00	18.1	117.0	105.0	4.0	4.90	0.75	0.23		0.98	5.88	0.409	0.77	5.00	15.43	15.38	3.4	103.6	0.148
20	4/7/96	20:00	156.00	18.0	117.0	105.0	4.0	5.00	0.76	0.25		1.01	6.01	0.418	0.75	4.95	15.63	15.63	3.1	103.9	0.151
21	4/8/96	8:00	168.00	18.1	118.0	105.0	4.0	4.90	0.75	0.25		1.00	5.90	0.410	0.75	4.90	15.43	15.38	3.2	104.3	0.147
22	4/8/96	20:00	180.00	18.0	118.0	105.0	4.0	5.00	0.74	0.23		0.97	5.97	0.416	0.76	5.15	15.22	15.22	3.5	104.0	0.146
23	4/9/96	8:00	192.00	18.2	118.0	105.0	4.0	5.00	0.74	0.24		0.98	5.98	0.417	0.76	5.10	15.22	15.13	3.3	104.2	0.145
24	4/9/96	20:00	204.00	18.2	118.0	105.0	4.0	4.80	0.75	0.24		0.99	5.79	0.402	0.76	4.85	15.43	15.34	3.4	104.1	0.147
25	4/10/96	8:00	216.00	18.3	119.0	105.0	4.0	5.10	0.75	0.24		0.99	6.09	0.424	0.76	5.15	15.43	15.29	3.5	104.5	0.146
26	4/10/96	20:00	228.00	18.3	119.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.50	3.4	104.6	0.148
27	4/11/96	8:00	240.00	18.3	119.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.50	3.2	104.8	0.148
28	4/11/96	20:00	252.00	18.4	119.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.25	3.3	104.7	0.146
29	4/12/96	8:00	264.00	18.3	119.0	105.0	4.0	4.90	0.73	0.26		0.99	5.89	0.410	0.74	4.95	15.02	14.88	2.9	105.1	0.142
30	4/12/96	20:00	276.00	18.3	119.0	105.0	4.0	5.10	0.74	0.24		0.98	6.08	0.424	0.76	5.20	15.22	15.09	3.3	104.7	0.144
31	4/13/96	8:00	288.00	18.2	119.0	105.0	4.0	5.00	0.74	0.24		0.98	5.98	0.417	0.76	5.10	15.22	15.13	3.2	104.8	0.144
32	4/13/96	20:00	300.00	18.1	120.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.38	3.2	105.3	0.146
33	4/14/96	8:00	312.00	18.0	120.0	105.0	4.0	4.90	0.75	0.25		1.00	5.90	0.410	0.75	4.90	15.43	15.43	3.3	105.2	0.147
34	4/14/96	20:00	324.00	18.1	120.0	105.0	4.0	5.00	0.75	0.23		0.98	5.98	0.416	0.77	5.10	15.43	15.38	3.4	105.1	0.146
35	4/15/96	8:00	336.00	18.0	120.0	105.0	4.0	4.90	0.76	0.25		1.01	5.91	0.411	0.75	4.85	15.63	15.63	3.2	105.3	0.148
36	4/15/96	20:00	348.00	18.2	120.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.34	3.3	105.2	0.146
37	4/16/96	8:00	360.00	18.2	121.0	105.0	4.0	5.00	0.74	0.23		0.97	5.97	0.416	0.76	5.15	15.22	15.13	3.4	105.6	0.143
38	4/16/96	20:00	372.00	18.3	120.0	105.0	4.0	4.80	0.74	0.24		0.98	5.78	0.402	0.76	4.90	15.22	15.09	3.1	105.4	0.143
39	4/17/96	8:00	384.00	18.3	121.0	105.0	4.0	5.10	0.75	0.24		0.99	6.09	0.424	0.76	5.15	15.43	15.29	3.3	105.7	0.145
40	4/17/96	20:00	396.00	18.3	121.0	105.0	4.0	5.10	0.75	0.24		0.99	6.09	0.424	0.76	5.15	15.43	15.29	3.2	105.8	0.145
41	4/18/96	8:00	408.00	18.4	121.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.45	3.3	105.7	0.146
42	4/18/96	20:00	420.00	18.3	121.0	105.0	4.0	5.00	0.76	0.25		1.01	6.01	0.418	0.75	4.95	15.63	15.50	3.3	105.7	0.147
43	4/19/96	8:00	432.00	18.3	121.0	105.0	4.0	4.90	0.75	0.25		1.00	5.90	0.410	0.75	4.90	15.43	15.29	3.2	105.8	0.145
44	4/19/96	20:00	444.00	18.2	122.0	105.0	4.0	5.10	0.73	0.26		0.99	6.09	0.425	0.74	5.15	15.02	14.93	3.2	106.3	0.140
45	4/20/96	8:00	456.00	18.1	122.0	105.0	4.0	5.00	0.74	0.24	X	0.98	5.98	0.417	0.76	5.10	15.22	15.18	3.2	106.3	0.143
46	4/20/96	20:00	468.00	18.2	112.0	105.0	4.0	5.00	0.74	0.24		0.98	5.98	0.417	0.76	5.10	15.22	15.13	3.2	101.3	0.149
47	4/21/96	8:00	480.00	18.2	114.0	105.0	4.0	4.90	0.75	0.25		1.00	5.90	0.410	0.75	4.90	15.43	15.34	3.2	102.3	0.150
48	4/21/96	20:00	492.00	18.4	114.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.25	3.3	102.2	0.149
49	4/22/96	8:00	504.00	18.3	114.0	105.0	4.0	5.00	0.75	0.23		0.98	5.98	0.416	0.77	5.10	15.43	15.29	3.4	102.1	0.150
50	4/22/96	20:00	516.00	18.2	115.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.54	3.4	102.6	0.151

Exhibit 7-6 Example Of Field 6 For The SEBST Data Sheet (page 1 of 2)

	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL
3	**Field E-6: Membrane Performance Data During Operation With The Test Water (continued)**																										
4																											
5	pH			TDS (mg/L)								UV_{254} (cm^{-1}), *Optional*								TOC (mg/L), *Optional*							
6	pH_p	pH_F	pH_C	TDS_p	TDS_F	TDS_C	$TDS_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	TDS_B	R_B (%)	UV_p	UV_F	UV_C	$UV_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	UV_B	R_B (%)	TOC_p	TOC_F	TOC_C	$TOC_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	TOC_B	R_B (%)
7	5.49	6.05	6.34	65.00	147.00	413.00	410.83	0.53	55.8	389.03	83.3	0.022	0.331		1.325		93.4	1.243	98.2	0.94	7.95		30.50		88.2	28.64	96.7
8	5.50	6.10	6.35	67.00	151.00	415.00	410.00	1.20	55.6	388.78	82.8	0.026	0.330	1.270	1.267	0.21	92.1	1.191	97.8	1.10	8.02	28.60	29.36	-2.65	86.3	27.61	96.0
9	5.61	6.11	6.30	65.50	150.00	412.00	414.06	-0.50	56.3	392.24	83.3																
10	5.45	6.03	6.30	64.00	150.00	411.00	418.75	-1.89	57.3	395.77	83.8																
11	5.50	6.00	6.38	63.00	153.00	415.00	426.60	-2.80	58.8	403.99	84.4	0.025	0.333	1.255	1.269	-1.14	92.5	1.192	97.9	1.03	7.95	28.00	28.99	-3.52	87.0	27.25	96.2
12	5.53	6.00	6.22	64.50	149.00	416.00	405.88	2.43	56.7	384.65	83.2																
13	5.55	6.02	6.24	65.00	149.00	418.00	401.00	4.07	56.4	380.34	82.9																
14	5.50	6.03	6.20	65.00	152.00	415.00	396.27	4.51	57.2	376.08	82.7																
15	5.67	6.03	6.20	66.00	153.00	417.00	421.25	-1.02	56.9	398.90	83.5	0.028	0.327		1.249		91.4	1.172	97.6	1.00	8.03		29.71		87.5	27.90	96.4
16	5.50	6.05	6.45	67.50	148.00	418.00	396.21	5.21	54.4	376.20	82.1	0.030	0.331	1.260	1.259	0.07	90.9	1.184	97.5	1.00	8.02	29.20	29.67	-1.59	87.5	27.92	96.4
17	5.44	6.00	6.44	66.00	150.00	416.00	402.00	3.37	56.0	381.00	82.7																
18	5.56	6.00	6.50	68.00	147.00	413.00	384.00	7.02	53.7	364.25	81.3	0.028	0.331		1.240		91.5	1.164	97.6	1.08	7.99		28.72		86.5	26.99	96.0
19	5.58	6.12	6.38	67.00	151.00	415.00	424.91	-2.39	55.6	402.09	83.3																
20	5.51	6.08	6.33	67.00	150.00	412.00	402.32	2.35	55.3	381.12	82.4																
21	5.53	5.98	6.30	65.00	150.00	411.00	405.00	1.46	56.7	383.39	83.0	0.028	0.329	1.250	1.232	1.44	91.5	1.155	97.6	0.98	8.00	29.50	29.06	1.49	87.8	27.28	96.4
22	5.52	6.00	6.30	65.00	153.00	415.00	436.13	-5.09	57.5	413.13	84.3	0.027	0.331		1.309		91.8	1.230	97.8	1.04	8.05		30.60		87.1	28.77	96.4
23	5.52	6.00	6.34	62.00	149.00	416.00	417.25	-0.30	58.4	395.27	84.3																
24	5.50	5.99	6.34	61.00	149.00	418.00	424.00	-1.44	59.1	400.49	84.8																
25	5.50	6.01	6.30	61.00	152.00	415.00	436.38	-5.15	59.9	413.26	85.2	0.024	0.331		1.290		92.7	1.212	98.0	0.96	7.96		29.84		87.9	28.06	96.6
26	5.58	6.04	6.30	62.00	153.00	417.00	429.64	-3.03	59.5	406.78	84.8																
27	5.61	6.03	6.41	63.00	148.00	418.00	406.40	2.78	57.4	385.04	83.6																
28	5.64	6.00	6.44	63.00	150.00	416.00	411.00	1.20	58.0	389.25	83.8																
29	5.56	6.00	6.40	65.00	147.00	413.00	377.23	8.66	55.8	357.88	81.8	0.029	0.333	1.250	1.187	5.08	91.3	1.115	97.4	1.04	8.07	28.60	27.81	2.77	87.1	26.15	96.0
30	5.50	6.03	6.30	66.00	151.00	415.00	413.08	0.46	56.3	391.96	83.2																
31	5.50	6.00	6.25	66.00	150.00	412.00	409.00	0.73	56.0	387.78	83.0	0.022	0.331		1.284		93.4	1.206	98.2	0.94	7.95		29.56		88.2	27.79	96.6
32	5.21	6.01	6.28	65.00	150.00	411.00	405.00	1.46	56.7	383.75	83.1																
33	5.38	6.03	6.30	64.00	153.00	415.00	420.00	-1.20	58.2	397.37	83.9	0.028	0.329		1.232		91.5	1.155	97.6	0.98	8.00		29.06		87.8	27.28	96.4
34	5.34	6.11	6.30	64.00	149.00	416.00	426.17	-2.45	57.0	403.46	84.1																
35	5.67	6.00	6.24	65.00	149.00	418.00	404.36	3.26	56.4	382.54	83.0	0.025	0.333	1.255	1.269	-1.14	92.5	1.189	97.9	1.03	7.95	28.00	28.99	-3.52	87.0	27.19	96.2
36	5.54	6.00	6.30	63.00	152.00	415.00	419.00	-0.96	58.6	396.75	84.1																
37	5.50	6.03	6.24	67.00	153.00	417.00	429.70	-3.04	56.2	407.22	83.5																
38	5.50	5.98	6.30	67.00	148.00	418.00	397.75	4.84	54.7	376.58	82.2	0.026	0.328	1.200	1.259	-4.93	92.1	1.180	97.8	0.96	8.00	28.00	29.71	-6.10	88.0	27.87	96.6
39	5.54	5.97	6.29	64.50	150.00	416.00	417.19	-0.29	57.0	395.47	83.7	0.028	0.327		1.261		91.4	1.185	97.6	1.00	8.03		30.00		87.5	28.21	96.5
40	5.50	6.00	6.30	65.00	147.00	413.00	403.25	2.36	55.8	382.42	83.0																
41	5.50	6.00	6.27	65.00	151.00	415.00	412.44	0.62	57.0	390.83	83.4																
42	5.57	6.09	6.30	62.00	150.00	412.00	417.52	-1.34	58.7	395.04	84.3																
43	5.48	6.03	6.24	63.50	150.00	411.00	409.50	0.36	57.7	387.51	83.6																
44	5.49	6.05	6.34	64.00	153.00	415.00	402.88	2.92	58.2	382.57	83.3	0.025	0.333	1.255	1.198	4.56	92.5	1.127	97.8	1.04	8.05	28.70	27.73	3.37	87.1	26.13	96.0
45	5.50	6.10	6.35	64.50	149.00	416.00	409.54	1.55	56.7	388.19	83.4																
46	5.61	6.11	6.30	66.00	149.00	418.00	404.92	3.13	55.7	383.95	82.8																
47	5.45	6.03	6.30	67.00	152.00	415.00	407.00	1.93	55.9	385.39	82.6																
48	5.50	6.00	6.38	66.00	153.00	417.00	414.00	0.72	56.9	392.25	83.2	0.028	0.331		1.240		91.5	1.164	97.6	0.96	8.00		29.12		88.0	27.36	96.5
49	5.50	6.00	6.27	63.00	148.00	418.00	425.17	-1.72	57.4	402.46	84.3																
50	5.57	6.09	6.30	61.00	150.00	416.00	420.56	-1.10	59.3	398.20	84.7	0.030	0.331	1.260	1.246	1.11	90.9	1.170	97.4	1.00	8.02	29.20	29.36	-0.55	87.5	27.60	96.4
51																											
52	**Exhibit 7-6 Example Of Field 6 For The SEBST Data Sheet (page 2 of 2)**																										

	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW
3	**Field E-7: Permeate, Feed, Concentrate And Blended Water Quality For Week 1**									
4	***Operating Parameters During Sample Collection***									
5	Recovery during sample collection (decimal)		0.75							
6	Feed flow rate during sample collection (gpm)		1.00							
7	Influent flow rate during sample collection (gpm)		5.90							
8										
9	***Permeate, Feed and Concentrate Water Quality***									
10	**Parameter**	**Units**	**C_p-1**	**C_F-1**	**C_C-1**	**$C_{C(calc)}$**	**$Error_{MB}$ (%)**	**R_F (%)**	**C_B**	**R_B (%)**
11	Sampling date	MM/DD/YY	4/8/96	4/8/96	4/8/96	---	---	---	---	---
12	Sampling time	hh:mm	8:00	8:00	8:00	---	---	---	---	---
13	Operation time	hh.hh	168.00	168.00	168.00	---	---	---	---	---
14	pH	---	5.53	5.98	6.30	---	---	---	---	---
15	Temperature	^oC	18.1	18.1	18.2	---	---	---	---	---
16	Alkalinity	mg/L as $CaCO_3$	35.0	75.0	202.0	195.0	3.47	53.3	184.8	81.1
17	Total dissolved solids	mg/L	65.0	150.0	411.0	405.0	1.46	56.7	383.4	83.0
18	Total hardness	mg/L as $CaCO_3$	108.0	320.0	952.0	956.0	-0.42	66.3	902.1	88.0
19	Calcium hardness	mg/L as $CaCO_3$	97.0	291.0	860.0	873.0	-1.51	66.7	823.7	88.2
20	Turbidity	ntu	0.10	0.80	3.00	2.90	3.33	87.5	2.72	96.3
21	Ammonia	mg NH_3-N / L	1.20	4.80	15.80	15.60	1.27	75.0	14.68	91.8
22	Total organic carbon	mg/L	0.98	8.00	29.50	29.06	1.49	87.8	27.28	96.4
23	UV_{254}	cm^{-1}	0.028	0.329	1.250	1.232	1.44	91.5	1.155475	97.6
24	SUVA	L/(mg*m)	2.86	4.11	4.24	---	---	---	---	---
25	Bromide	μg/L	151.0	250.0	---	547.0	---	39.6	521.8	71.1
26	SDS-Cl_2 dose	mg/L	1.80	12.00	---	---	---	---	---	---
27	SDS-Free Cl_2 residual	mg/L	0.90	0.90	---	---	---	---	---	---
28	SDS-Cl_2 demand	mg/L	0.90	11.10	---	41.70	---	91.9	39.10678	97.7
29	SDS-Chlorination temp.	^oC	18.8	18.8	---	---	---	---	---	---
30	SDS-Chlorination pH	---	7.86	7.88	---	---	---	---	---	---
31	SDS-Incubation time	hours	84.5	84.5	---	---	---	---	---	---
32	SDS-TOX	μg Cl^-/L	52.00	980.00	---	3764.00	---	94.7	3528.07	98.5
33	SDS-*CHCl3*	μg/L	12.80	162.00	---	609.60	---	92.1	571.67	97.8
34	SDS-*BDCM*	μg/L	10.30	48.00	---	161.10	---	78.5	151.52	93.2
35	SDS-*DBCM*	μg/L	9.60	10.00	---	11.20	---	4.0	11.10	13.5
36	SDS-*CHBr3*	μg/L	0.87	0.45	---	-0.81	---	-93.3	-0.70	223.7
37	SDS-THM4	μg/L	33.57	220.45	---	781.09	---	84.8	733.58	95.4
38	SDS-*MCAA**	μg/L	BMRL	4.10	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
39	SDS-*DCAA**	μg/L	5.63	30.50	---	105.11	---	81.5	98.79	94.3
40	SDS-*TCAA**	μg/L	8.25	58.90	---	210.85	---	86.0	197.97	95.8
41	SDS-*MBAA**	μg/L	BMRL	0.97	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
42	SDS-*DBAA**	μg/L	4.23	2.86	---	-1.25	---	-47.9	-0.90	569.1
43	SDS-*BCAA**	μg/L	8.68	21.30	---	59.16	---	59.2	55.95	84.5
44	SDS-*TBAA*	μg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
45	SDS-*CDBAA*	μg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
46	SDS-*DCBAA*	μg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
47	SDS-HAA5	μg/L	18.11	97.33	---	334.99	---	81.4	314.85	94.2
48	SDS-HAA6	μg/L	26.79	118.63	---	394.15	---	77.4	370.80	92.8
49	BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported									
50	*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.									
51										
52	***Blending Calculations For D-DBP MCLs***									
53		**THM4 Controls**				**HAA5 Controls**				
54		Stage 1	Stage 2			Stage 1	Stage 2			
55	Q_p/Q_T (THM4), %	79.4	98.7		Q_p/Q_T (HAA5), %	54.7	88.8			
56	SDS-$THM4_b$, μg/L	72.00	36.00		SDS-$THM4_b$, μg/L	118.23	54.54			
57	SDS-$HAA5_b$, μg/L	34.40	19.14		SDS-$HAA5_b$, μg/L	54.00	27.00			
58	SDS-TOX_b, μg Cl^-/L	242.83	64.07		SDS-TOX_b, μg Cl^-/L	472.42	156.14			
59	SDS-CD_b, mg/L	3.00	1.03		SDS-CD_b, mg/L	5.52	2.04			
60	TOC_b, mg/L	2.42	1.07		TOC_b, mg/L	4.16	1.77			
61	$UV_{254\,b}$, cm^{-1}	0.090	0.032		$UV_{254\,b}$, cm^{-1}	0.164	0.062			
62	$Bromide_b$, μg/L	171.4	152.3		$Bromide_b$, μg/L	195.9	162.1			
63	Alk_b, mg/L $CaCO_3$	43.2	35.5		Alk_b, mg/L $CaCO_3$	53.1	39.5			
64	T-Hd_b, mg/L $CaCO_3$	151.6	110.8		T-Hd_b, mg/L $CaCO_3$	204.0	131.8			
65	Ca-Hd_b, mg/L $CaCO_3$	136.9	99.5		Ca-Hd_b, mg/L $CaCO_3$	184.9	118.8			
66	Notes:									
67	This field uses the feed and permeate water quality parameters entered above to determine the percentage of total flow that must be									
68	treated by the membrane process to meet the Stage 1 and proposed Stage 2 DBP MCLs.									
69	A 10% factor of safety has been applied all the MCLs. i.e., MCLs for Stage 1 are 72 / 54 μg/L and Stage 2 are 36 / 27 μg/L for THM4 and HAA5.									
70	Since either THM4 or HAA5 can control the allowable blend ratio, the blend ratio is calculated for both parameters.									
71	**The maximum (Q_p/Q_T) ratio controls the design.**									
72	Q_p/Q_T (THM4) is the permeate to total flow ratio for the case where THM4 controls the blend ratio.									
73	Q_p/Q_T (HAA5) is the permeate to total flow ratio for the case where HAA5 controls the blend ratio.									
74	The subscript "b" refers to the blended water quality for a given blend ratio.									
75	If the permeate quality does not meet the MCL prior to blending, then these calculations are meaningless for that MCL.									
76	If the feed water quality meets the MCL, then a negative ratio will be calculated for that MCL.									
77										
78	**Exhibit 7-7 Example Of Field 7 For The SEBST Data Sheet**									

	DF	DG	DH	DI	DJ	DK	DL	DM	DN	DO
3	**Field E-11: Duplicate Analysis Of Permeate, Feed, Concentrate And Blended Water Quality For Week __1__**									
4	***Operating Parameters During Sample Collection***									
5	Recovery during sample collection (decimal)		0.75							
6	Feed flow rate during sample collection (gpm)		1.00							
7	Influent flow rate during sample collection (gpm)		5.90							
8										
9	***Permeate, Feed and Concentrate Water Quality***									
10	**Parameter**	**Units**	**C_p-1 (dup)**	**C_F-1 (dup)**	**C_C-1 (dup)**	**$C_{C(calc)}$**	**$Error_{MB}$ (%)**	**R_F (%)**	**C_B**	**R_B (%)**
11	Sampling date	MM/DD/YY	4/8/96	4/8/96	4/8/96	---	---	---	---	---
12	Sampling time	hh:mm	8:00	8:00	8:00	---	---	---	---	---
13	Operation time	hh.hh	168.00	168.00	168.00	---	---	---	---	---
14	pH	---	5.56	6.01	6.27	---	---	---	---	---
15	Temperature	^oC	18.1	18.1	18.2	---	---	---	---	---
16	Alkalinity	mg/L as $CaCO_3$	37.0	79.0	201.0	205.0	-1.99	53.2	194.3	81.0
17	Total dissolved solids	mg/L	60.0	144.0	402.0	396.0	1.49	58.3	374.6	84.0
18	Total hardness	mg/L as $CaCO_3$	101.0	320.0	952.0	977.0	-2.63	68.4	921.3	89.0
19	Calcium hardness	mg/L as $CaCO_3$	97.0	284.0	840.0	845.0	-0.60	65.8	797.5	87.8
20	Turbidity	ntu	0.08	1.05	4.02	3.96	1.49	92.4	3.71	97.8
21	Ammonia	mg NH_3-N / L	1.15	4.80	15.80	15.75	0.32	76.0	14.82	92.2
22	Total organic carbon	mg/L	1.02	7.98	28.60	28.86	-0.91	87.2	27.09	96.2
23	UV_{254}	cm^{-1}	0.026	0.329	1.250	1.238	0.96	92.1	1.160966	97.8
24	SUVA	L/(mg*m)	2.55	4.12	4.37	---	---	---	---	---
25	Bromide	µg/L	148.0	254.0	---	572.0	---	41.7	545.1	72.8
26	SDS-Cl_2 dose	mg/L	1.90	11.80	---	---	---	---	---	---
27	SDS-Free Cl_2 residual	mg/L	1.00	1.05	---	---	---	---	---	---
28	SDS-Cl_2 demand	mg/L	0.90	10.75	---	40.30	---	91.6	37.79576	97.6
29	SDS-Chlorination temp.	^oC	18.8	18.8	---	---	---	---	---	---
30	SDS-Chlorination pH	---	7.86	7.88	---	---	---	---	---	---
31	SDS-Incubation time	hours	84.5	84.5	---	---	---	---	---	---
32	SDS-TOX	µg Cl^-/L	48.00	965.00	---	3716.00	---	95.0	3482.86	98.6
33	SDS-*CHCl3*	µg/L	14.30	160.00	---	597.10	---	91.1	560.06	97.4
34	SDS-*BDCM*	µg/L	11.60	46.00	---	149.20	---	74.8	140.45	91.7
35	SDS-*DBCM*	µg/L	10.94	9.86	---	6.62	---	-11.0	6.89	-58.7
36	SDS-*CHBr3*	µg/L	0.87	BMRL	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
37	SDS-THM4	µg/L	37.71	215.86	---	750.31	---	82.5	705.02	94.7
38	SDS-*MCAA**	µg/L	BMRL	4.10	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
39	SDS-*DCAA**	µg/L	5.63	30.50	---	105.11	---	81.5	98.79	94.3
40	SDS-*TCAA**	µg/L	8.05	58.90	---	211.45	---	86.3	198.52	95.9
41	SDS-*MBAA**	µg/L	BMRL	0.97	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
42	SDS-*DBAA**	µg/L	5.10	3.12	---	-2.82	---	-63.5	-2.32	320.1
43	SDS-*BCAA**	µg/L	8.68	21.30	---	59.16	---	59.2	55.95	84.5
44	SDS-*TBAA*	µg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
45	SDS-*CDBAA*	µg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
46	SDS-*DCBAA*	µg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
47	SDS-HAA5	µg/L	18.78	97.59	---	334.02	---	80.8	313.98	94.0
48	SDS-HAA6	µg/L	27.46	118.89	---	393.18	---	76.9	369.94	92.6

49 BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported
50 *: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.
51
52 ***Blending Calculations For D-DBP MCLs***

		THM4 Controls			**HAA5 Controls**	
53						
54		Stage 1	Stage 2		Stage 1	Stage 2
55	Q_p/Q_T (THM4), %	80.8	101.0	Q_p/Q_T (HAA5), %	55.3	89.6
56	SDS-$THM4_b$, µg/L	72.00	NA	SDS-$THM4_b$, µg/L	117.32	56.29
57	SDS-$HAA5_b$, µg/L	33.95	NA	SDS-$HAA5_b$, µg/L	54.00	27.00
58	SDS-TOX_b, µg Cl^-/L	224.50	NA	SDS-TOX_b, µg Cl^-/L	457.81	143.64
59	SDS-CD_b, mg/L	2.80	NA	SDS-CD_b, mg/L	5.30	1.93
60	TOC_b, mg/L	2.36	NA	TOC_b, mg/L	4.13	1.75
61	$UV_{254\ b}$, cm^{-1}	0.084	NA	$UV_{254\ b}$, cm^{-1}	0.161	0.058
62	$Bromide_b$, µg/L	168.4	NA	$Bromide_b$, µg/L	195.4	159.1
63	Alk_b, mg/L $CaCO_3$	45.1	NA	Alk_b, mg/L $CaCO_3$	55.8	41.4
64	T-Hd_b, mg/L $CaCO_3$	143.2	NA	T-Hd_b, mg/L $CaCO_3$	198.9	123.8
65	Ca-Hd_b, mg/L $CaCO_3$	133.0	NA	Ca-Hd_b, mg/L $CaCO_3$	180.6	116.5

66 Notes:
67 This field uses the feed and permeate water quality parameters entered above to determine the percentage of total flow that must be
68 treated by the membrane process to meet the Stage 1 and proposed Stage 2 DBP MCLs.
69 A 10% factor of safety has been applied all the MCLs. i.e., MCLs for Stage 1 are 72 / 54 µg/L and Stage 2 are 36 / 27 µg/L for THM4 and HAA5.
70 Since either THM4 or HAA5 can control the allowable blend ratio, the blend ratio is calculated for both parameters.
71 **The maximum (Q_p/Q_T) ratio controls the design.**
72 Q_p/Q_T (THM4) is the permeate to total flow ratio for the case where THM4 controls the blend ratio.
73 Q_p/Q_T (HAA5) is the permeate to total flow ratio for the case where HAA5 controls the blend ratio.
74 The subscript "b" refers to the blended water quality for a given blend ratio.
75 If the permeate quality does not meet the MCL prior to blending, then these calculations are meaningless for that MCL.
76 If the feed water quality meets the MCL, then a negative ratio will be calculated for that MCL.
77
78 **Exhibit 7-8 Example Of Field 11 For The SEBST Data Sheet**

	DQ	DR
3	**Field E-12: Membrane Cost Parameters**	
4	***General Cost Parameters***	
5	**Cost Parameter**	**Parameter value**
6	Capital Recovery Interest Rate (%)	10
7	Capital Recovery Period (years)	20
8	Overhead & Profit Factor (% of construction costs)	5
9	Special Sitework Factor (% of construction costs)	5
10	Construction Contingencies (% of construction costs)	10
11	Engineering Fee Factor (% of construction costs)	10
12	1998 ENR Construction Cost Index (CCI base year 1913)	####
13	1998 Producers Price Index (PPI base year 1967 = 100)	###
14	Labor Rate + Fringe ($/work-hour)	15
15	Labor Overhead Factor (% of labor)	10
16	Electric Rate ($/kW-h)	0.086
17	Fuel Oil Rate ($/gal)	0.89
18	Natural Gas Rate ($/ft^3)	0.0055
19	Current Process Water Rate ($/1000 gal)	0.35
20	Modifications to Existing Plant (% of construction costs)	5
21		
22	**Exhibit 7-9 Example Of Field 12 For The SEBST Data Sheet**	

Appendix 7a: Membrane SEBST Equations And Nomenclature

Nomenclature

A	Active membrane area of the full-scale element used in the SEBST **(ft^2)**
BCAA	Bromochloroacetic acid **(μg/L)**
BDCAA	Bromodichloroacetic acid **(μg/L)**
BDCM	Bromodichloromethane **(μg/L)**
BMRL	Blow minimum reporting level
$\mathbf{C_b}$	Concentration of a blended sample (i.e., feed:permeate blend)
$\mathbf{C_B}$	Concentration in bulk solution
$\mathbf{C_C}$	Concentration in the concentrate stream (i.e., waste and recycle streams)
$\mathbf{C_{C(calc)}}$	Concentrate concentration based on mass balance calculations
$\mathbf{C_F}$	Concentration in the feed stream
$\mathbf{C_p}$	Concentration in the permeate stream
$\mathbf{C_{TG}}$	Treatment goal concentration (e.g., 72μg/L for 90% Stage 1 THM4 MCL)
CHBr3	Bromoform **(μg/L)**
CHCl3	Chloroform **(μg/L)**
DBAA	Dibromoacetic acid **(μg/L)**
DBCAA	Dibromochloroacetic acid **(μg/L)**
DBCM	Dibromochloromethane **(μg/L)**
DCAA	Dichloroacetic acid **(μg/L)**
$\mathbf{Error_{MB}}$	Mass balance closure error **(%)**
$\mathbf{F}_{W\text{-}\mathbf{design}}$	Design permeate water flux **(gfd)**
$\mathbf{F}_W\mathbf{(T°C)}$	Water flux at ambient temperature, T°C, **(gfd)**
$\mathbf{F}_W\mathbf{(Tavg°C)}$	Water flux at the average yearly water temperature, Tavg°C, **(gfd)**
LSI	Langelier saturation index
MBAA	Monobromoacetic acid **(μg/L)**
MCAA	Monochloroacetic acid **(μg/L)**
MFI	Modified fouling index
MPFI	Mini plugging factor index
$\mathbf{MTC}_W$	Water mass transfer coefficient **(gfd/psi)**
$\mathbf{MTC}_W\mathbf{(Tavg°C)}$	Water mass transfer coefficient at average temperature, Tavg°C, **(gfd/psi)**
NA	Not analyzed
NDP	Net driving pressure **(psi)**
NR	Not reported
$\mathbf{P_C}$	Pressure of the concentrate stream **(psi)**
$\mathbf{P_I}$	Pressure of the influent stream **(psi)**
$\mathbf{P_p}$	Design permeate pressure **(psi)**
$\mathbf{Q_F}$	Feed flow rate **(gpm)**
$\mathbf{Q_I}$	Influent flow rate **(gpm)**
$\mathbf{Q_p}$	Permeate flow rate **(gpm)**
$\mathbf{Q_R}$	Concentrate-recycle flow rate **(gpm)**
$\mathbf{Q_T}$	Total product flow rate (i.e., permeate flow plus by-passed feed flow) **(gpm)**
$\mathbf{Q_W}$	Concentrate-waste flow rate **(gpm)**

r	Recycle ratio
$\mathbf{r_b}$	Permeate:total product flow blend ratio (i.e., $\mathbf{Q_p/Q_T}$)
R	Recovery **(decimal fraction)**
$\mathbf{R_B}$	Rejection based on the bulk concentration **(%)**
$\mathbf{R_F}$	Rejection based on the feed concentration **(%)**
$\mathbf{Rej_{TDS}}$	Manufacturer reported TDS rejection **(decimal fraction)**
SDI	Silt density index
SDS	Simulated distribution system
SDS-CD	SDS chlorine demand **(mg/L)**
SDS-Cl Dose	SDS chlorine dose **(mg/L)**
SDS-CR	SDS free chlorine residual **(mg/L)**
SDS-HAA5	The sum of five haloacetic acids evaluated under SDS conditions **(μg/L)**
SDS-HAA6	The sum of six haloacetic acids evaluated under SDS conditions **(μg/L)**
SDS-THM4	The sum of four trihalomethanes evaluated under SDS conditions **(μg/L)**
SDS-TOX	Total organic halides evaluated under SDS conditions **(μg $\mathbf{Cl^-}$/L)**
SUVA	Specific ultraviolet absorbance **(L/(mg*m))**
T	Thickness of the mesh feed spacer used in the full-scale element **(ft)**
T°C	Ambient temperature **(°C)**
Tavg°C	Average yearly water temperature at the plant **(°C)**
TBAA	Tribromoacetic acid **(μg/L)**
TCAA	Trichloroacetic acid **(μg/L)**
TDS	Total dissolved solids **(mg/L)**
$\mathbf{TDS_F}$	Total dissolved solids in the feed stream **(mg/L)**
$\mathbf{TDS_I}$	Total dissolved solids in the influent stream **(mg/L)**
$\mathbf{TDS_p}$	Total dissolved solids in the permeate stream **(mg/L)**
$\mathbf{TDS_W}$	Total dissolved solids in the concentrate-waste stream **(mg/L)**
TOC	Total organic carbon **(mg/L)**
$\mathbf{UV_{254}}$	Ultra-violet absorbance at 254 nm **($\mathbf{cm^{-1}}$)**
$\mathbf{v_c}$	Cross-flow velocity **(fps)**
w	Total width of all membrane envelopes in the SEBST element **(ft)**
$\Delta\pi$	Estimated osmotic pressure gradient **(psi)**
$\Delta\mathbf{P_{loss}}$	Estimated system pressure losses **(psi)**

SEBST Design Calculations

Temperature Normalized MTC_W (Example cell: H6)

$$\mathbf{MTC_W(Tavg°C) = MTC_W(T°C) \times 1.03^{(Tavg°C - T°C)}} \qquad \textbf{(7a.1)}$$

Permeate Flow Rate (Example cell: H11)

$$\mathbf{Q_p = F_{W\text{-design}} \times A / 1440 \text{ (min per day)}} \qquad \textbf{(7a.2)}$$

Feed Flow Rate (Example cell: H12)

$$\mathbf{Q_F = Q_p / R} \qquad \textbf{(7a.3)}$$

Concentrate-Waste Flow Rate (Example cell: H13)

$$\mathbf{Q_W = Q_F - Q_p} \qquad \textbf{(7a.4)}$$

Concentrate-Recycle Flow Rate (Example cell: H17)

$$\mathbf{Q_R = Q_I - Q_F} \qquad \textbf{(7a.5)}$$

Recycle Ratio (Example cell: H18)

$$\mathbf{r = Q_R/Q_F} \qquad \textbf{(7a.6)}$$

Estimate of Concentrate-Waste, Permeate and Influent TDS Concentrations

Estimate of Concentrate-Waste TDS Concentration (Example cell: H27)

$$\mathbf{TDS_W = TDS_F \times (1 + r - R + (R \times Rej_{TDS}))/(1 + r - R - (r \times R \times Rej_{TDS}))} \qquad \textbf{(7a.7)}$$

Estimate of Permeate TDS Concentration (Example cell: H28)

$$\mathbf{TDS_p = (Q_F \times TDS_F - Q_W \times TDS_W)/Q_p} \qquad \textbf{(7a.8)}$$

Estimate of Influent TDS Concentration (Example cell: H29)

$$\mathbf{TDS_I = (Q_F \times TDS_F + r \times Q_F \times TDS_W)/Q_I} \qquad \textbf{(7a.9)}$$

Estimate of Osmotic and Influent Pressures

Osmotic Pressure For Design Calculations (Example cell: H30)

$$\mathbf{\Delta\pi = 0.01 \times (((TDS_I + TDS_W)/2) - TDS_p)} \qquad \textbf{(7a.10)}$$

Design Influent Pressure (Example cell: H35)

$$\mathbf{P_I = F_W(Tavg°C)/MTC_W + \Delta P_{loss} + P_p + \Delta\pi} \qquad \textbf{(7a.11)}$$

Membrane Operating Parameters and Productivity

Feed Flow Rate (Example cells: AB7:AB50)

$$\mathbf{Q_F = Q_p + Q_W} \qquad \textbf{(7a.12)}$$

Influent Flow Rate (Example cells: AC7:AC50)

$$\mathbf{Q_I = Q_F + Q_R} \qquad \textbf{(7a.13)}$$

Cross-Flow Velocity (Example cells: AD7:AD50)

$$\mathbf{v_c = (Q_I - 0.5 \times Q_p)/(w \times T)) \times 2.228 \times 10^{-3} \text{ (cfs per gpm)}} \qquad \textbf{(7a.14)}$$

System Recovery (Example cells: AE7:AE50)

$$\mathbf{R = Q_p / Q_F} \qquad \mathbf{(7a.15)}$$

Recycle Ratio (Example cells: AF7:AF50)

$$\mathbf{r = Q_R / Q_F} \qquad \mathbf{(7a.16)}$$

Water Flux at Ambient Temperature (Example cells: AG7:AG50)

$$\mathbf{F_{\mathit{W}}(T°C) = (Q_p / A) \times 1440\ (min\ per\ day)} \qquad \mathbf{(7a.17)}$$

Water Flux at Average Water Temperature (Example cells: AH7:AH50)

$$\mathbf{F_{\mathit{W}}(Tavg°C) = F_{\mathit{W}}(T°C) \times 1.03^{(Tavg°C - T°C)}} \qquad \mathbf{(7a.18)}$$

Estimate of Osmotic Pressure Gradient (Example cells: AI7:AI50)

$$\mathbf{\Delta\pi = 0.01 \times (TDS_B - TDS_p)} \qquad \mathbf{(7a.19)}$$

Net Driving Pressure (Example cells: AJ7:AJ50)

$$\mathbf{NDP = ((P_I + P_C)/2) - P_p - \Delta\pi} \qquad \mathbf{(7a.20)}$$

Water Mass Transfer Coefficient at Average Temperature (Example cells: AK7 - AK52)

$$\mathbf{MTC_{\mathit{W}}(Tavg°C) = F_{\mathit{W}}(Tavg°C) / NDP} \qquad \mathbf{(7a.21)}$$

<u>Water Quality Analysis</u>

SDS-Chlorine Demand (Example cells: BP28:BQ28, CA28:CB28, CL28:CM28, CW28:CX28, DH28:DI28)

$$\mathbf{(SDS\text{-}CD) = (SDS\text{-}Cl\ Dose) - (SDS\text{-}CR)} \qquad \mathbf{(7a.22)}$$

SDS-HAA5 (Example cells: BP47:BQ47, CA47:CB47, CL46:CM47, CW47:CX47, DH47:DI47)

$$\mathbf{SDS\text{-}HAA5 = MCAA + DCAA + TCAA + MBAA + DBAA} \qquad \mathbf{(7a.23)}$$

SDS-HAA6 (Example cells: BP48:BQ48, CA48:CB48, CL48:CM48, CW48:CX48, DH48:DI48)

$$\mathbf{SDS\text{-}HAA6 = MCAA + DCAA + TCAA + MBAA + DBAA + BCAA} \qquad \mathbf{(7a.24)}$$

SDS-THM4 (Example cells: BP37:BQ37, CA37:CB37, CL37:CM37, CW37:CX37, DH37:DI37)

$$\mathbf{SDS\text{-}THM4 = CHCl3 + BDCM + DBCM + CHBr3} \qquad \mathbf{(7a.25)}$$

Calculated Concentrate Concentration (Example cells: AR7:AR50, AZ7:AZ50, BH7:BH50, BS16:BS48, CD16:CD48, CO16:CO48, CZ16:CZ48, DK16:DK48)

$$\mathbf{C_{C(calc)} = (C_F - R \times C_p) / (1\text{-}R)} \qquad \mathbf{(7a.26)}$$

Mass Balance Closure Error (Example cells: AS7:AS50, BA7:BA50, BI7:BI50, BT16:BT23, CE16:CE23, CP16:CP23, DA16:DA23, DL16:DL23)

$$\mathbf{Error_{MB} = ((C_C - C_{C(calc)}) / C_C) \times 100\%} \qquad \mathbf{(7a.27)}$$

Feed Rejection (Example cells: AT7:AT50, BB7:BB50, BJ7:BJ50, BU16:BU48, CF16:CF48, CQ16:CQ48, DB16:DB48, DM16:DM48)

$$\mathbf{R_F = ((C_F - C_p)/C_F) \times 100\%} \qquad \mathbf{(7a.28)}$$

Bulk Concentration (Example cells:AU7:AU50, BC7:BC50, BK7:BK50, BV16:BV48, CG16:CG48, CR16:CR48, DC16:DC48, DN16:DN48)

$$\mathbf{C_B = (C_F \times Q_F + C_C \times (2 \times Q_I - Q_F))/2 \times Q_I} \qquad \textbf{(7a.29)}$$

Bulk Rejection (Example cells:AV7:AV50, BD7:BD50, BL7:BL50, BW16:BW48, CH16:CH48, CS16:CS48, DD16:DD48, DO16:DO48)

$$\mathbf{R_B = ((C_B - C_p)/C_B) \times 100\%} \qquad \textbf{(7a.30)}$$

Blend Ratio (Example cells: BO55:BT55, BZ55:CE55, CK55:CP55, CV55:DA55, DG55:DL55)

$$\mathbf{r_b = Q_p/Q_T = (C_F - C_{TG})/(C_F - C_p)} \qquad \textbf{(7a.31)}$$

C_{TG}(THM4, Stage 1) = 72 μg/L; C_{TG}(HAA5, Stage 1) = 54 μg/L;
C_{TG}(THM4, Stage 2) = 36 μg/L; C_{TG}(HAA5, Stage 2) = 27 μg/L

Blended Water Quality (Example cells: BO56:BT65, BZ56:CE65, CK56:CP65, CV56:DA65, DG56:DL65)

$$\mathbf{C_b = r_b \times (C_p - C_F) + C_F} \qquad \textbf{(7a.32)}$$

SUVA (Example cells: BP24:BR24, CA24:CC24, CL24:CN24, CW24:CY24, DH24:DJ24)

$$\mathbf{SUVA = (UV_{245}/TOC) \times 100 (cm/m)} \qquad \textbf{(7a.33)}$$

8.0 Spreadsheet For Membrane LT-SEBST Bench-Scale Studies

The LT-SEBST spreadsheet (*ltsebst.xls)* is designed to contain the data from one Long-Term SEBST study. This spreadsheet consists of six (6) field-sets with thirteen (13) fields in each field-set. Each field-set is located on a separate worksheet, and Table 8-1 summarizes the designation, sheet title and cell range for each field-set.

Field-Set Title (Designation)	Sheet Title	Field-Set Cell Range
Example Long-Term SEBST Data (E-)	Sheet0. Example Data	A1:EC76
LT-SEBST Results: Weeks 1-10 (1-)	Sheet1. Weeks 1-10	A1:EC220
LT-SEBST Results: Weeks 11-20 (2-)	Sheet2. Weeks 11-20	A1:EC220
LT-SEBST Results: Weeks 21-30 (3-)	Sheet3. Weeks 21-30	A1:EC220
LT-SEBST Results: Weeks 31-40 (4-)	Sheet4. Weeks 31-40	A1:EC220
LT-SEBST Results: Weeks 41-50 (5-)	Sheet5. Weeks 41-50	A1:EC220

Table 8-1 Summary Of Long-Term SEBST Field-Sets And Corresponding Sheet Titles

The Example Field-Set demonstrates the use of the LT-SEBST spreadsheet. Example data are presented in each field to clarify the use of these spreadsheets and to verify that the equations are functioning properly. The entire Example Field-Set is Locked and Protected to prevent data entry on this sheet. Each of the Field-Sets 1 through 5, are used to enter the results from ten weeks of Long-Term SEBST operation. For example, Field-Set 1 is used to report the results from weeks 1 through 10, Field-Set 2 is used to report the results from weeks 11 through 20, Field-Set 3 is used to report the results from weeks 21 through 30 etc.

The thirteen fields in each field-set are identified by the field-set designation (i.e., E, 1, 2, 3, 4, or 5) followed by a field designation (i.e., 1 through 13). For example, Field 1-6 is the sixth field in Field-Set 1, and Field 5-6 is the sixth field in Field-Set 5. Furthermore, fields with the same *field designation* are identical (e.g., Field 1-6 is the same as Field 5-6 except that Field 1-6 is used to report results from the first ten weeks of Long-Term SEBST operation, and Field 5-6 is used to report results from the last ten weeks of Long-Term SEBST operation). The field titles, designations and cell ranges are summarized in Table 8-2, and the individual fields are described in Sections 8.1 through 8.13.

8.1 Field 1: PWS And Treatment Plant Data *(A3:B30)*

Exhibit 8-1 presents an example of Field 1 which is used to enter the Public Water System (PWS) and treatment plant data, including the PWSID#, plant ICR #, and addresses and phone numbers of the official and technical ICR contacts. Some of the information in Field 1 is optional (i.e., the WIDB number and e-mail addresses).

Field Title	Designation	Field Cell Range
PWS and Treatment Plant Data	1	A3:B30
Manufacturer Reported Membrane Characteristics	2	D3:E45
SEBST Design Parameters	3	G3:H35
Foulants and Fouling Indices	4	J3:K29
Pretreatment Used Prior to Membranes	5	M3:O24
Membrane Performance Data During Operation With The Test Water	6	Q3:BL220
Permeate, Feed, Concentrate And Blended Water Quality For Week 2 (12, 22, 32, 42)[1]	7	BN3:BW76
Permeate, Feed, Concentrate And Blended Water Quality For Week 4 (14, 24, 34, 44)	8	BY3:CH76
Permeate, Feed, Concentrate And Blended Water Quality For Week 6 (16, 26, 36, 46)	9	CJ3:CS76
Permeate, Feed, Concentrate And Blended Water Quality For Week 8 (18, 28, 38, 48)	10	CU3:DD76
Permeate, Feed, Concentrate And Blended Water Quality For Week 10 (20, 30, 40, 50)	11	DF3:DO76
Duplicate Analysis Of Permeate, Feed, Concentrate And Blended Water Quality For Week 10 (20, 30, 40, 50)	12	DQ3:DZ76
Membrane Cost Parameters	13	EB3:EC20

1: The numbers in parentheses are the week designations for the second, third, fourth and fifth field-sets. For example, Field 10 is used to report results from week 8 in Field-Set 1, week 18 in Field-Set 2, week 28 in Field-Set 3, week 38 in Field-Set 4 and week 48 in Field-Set 5.

Table 8-2 Summary Of Long-Term SEBST Data Fields

8.2 Field 2: Manufacturer Reported Membrane Characteristics *(D3:E45)*

Exhibit 8-2 presents an example of Field 2 which is used to enter the manufacturer reported characteristics of the membrane used in the Long-Term SEBST study. The first block of cells in Field 2, ***General Information (D4:E12)***, is used to enter information including the membrane manufacturer, trade name, membrane element model number, molecular weight cutoff, etc. The second block, ***Design Parameters (D14:E26)***, is used to enter values for the parameters that will be used in the design of the Long-Term SEBST study, and all of the information in this block **must** be entered including:

- The size of the element used during the study, such as a 2.5" x 40" element or a 4" x 40" element. (The minimum element size that can be used is a 2.5" x 40".)

- The active membrane area of the element used (A) in **ft^2**.
- The design flux (F_W) in **gfd**.
- The net driving pressure (NDP) at this design flux in **psi**.
- The water mass transfer coefficient, or water flux per unit of net driving pressure (MTC_W) in **gfd/psi**. (If the MTC_W is not explicitly reported by the manufacturer, it can be calculated by dividing the design flux by the net driving pressure at this design flux.)
- The temperature (T°C) at which the design flux or MTC_W was measured in **°C**.
- The maximum ($Q_{I, max}$) and minimum ($Q_{I, min}$) allowable flow rates to the element used in the study in **gpm**.
- The total width of all membrane envelopes in the element used in the study (w) in **ft** (i.e., this is the *width* of the feed flow channel in the membrane element).
- The thickness of the feed spacer in the element used in the study (T) in **ft** (i.e., this is the *thickness* of the feed flow channel in the membrane element).
- The active membrane area of an equivalent 8" x 40" membrane element in **ft^2**.
- The purchase price of an equivalent 8" x 40" membrane element in **$**.

The third block in this field ***(D28:E43)*** is used to enter additional information reported by the manufacturer such as the required feed flow to permeate flow rate ratio, the maximum element recovery, and other information that could be used during the design of the Long-Term SEBST study.

8.3 Field 3: SEBST Design Parameters *(G3:H35)*

Exhibit 8-3 presents an example of Field 3 which uses information entered in Field 2 as well as design parameters entered in Field 3, to calculate the operating parameters for the Long-Term SEBST studies.

In the first block of this field, ***Calculate Temperature Normalized MTC_W (G4:H6)***, the user must enter the average yearly water temperature of the feed water at the plant in **°C**, and the spreadsheet will calculated the MTC_W normalized to this average yearly water temperature. In the second block, ***Calculate System Flow Rates (G8:H22)***, the user must enter the design recovery as a decimal fraction (i.e., this should be 0.75 according to the requirements in the *ICR Manual for Bench- and Pilot- Scale Treatment Studies*). The spreadsheet calculates the following flow rates in gallons per minute:

- The permeate flow rate (Q_p) in **gpm**.
- The feed flow rate (Q_F) in **gpm**.
- The concentrate-waste flow rate (Q_W) in **gpm**.
- The minimum required influent flow rate to the element ($Q_{I, min}$) in **gpm**.
- The maximum allowable influent low rate to the element ($Q_{I, max}$) in **gpm**.

The user must then enter the design influent flow rate (Q_I), which must be in the range established by the minimum and maximum influent flow rates. The spreadsheet will then use this information to calculate the required recycle flow rate (Q_R) and recycle ratio (r).

In the third block in this field, ***Estimate the Osmotic Pressure Gradient (G24:H30)***, the user must enter the TDS rejection (Rej_{TDS}) of the membrane being investigated along with the approximate TDS concentration of the feed to the membrane system (TDS_F). The TDS rejection can either be obtained from the manufacturer or measured directly, but the TDS rejection should be evaluated at a low recovery (i.e., < 30%) to approximate the bulk rejection. The spreadsheet uses the entered TDS rejection and feed TDS concentration to calculate the waste, permeate and influent TDS concentrations which are used to estimate the osmotic pressure gradient ($\Delta\pi$).

The fourth block of this field, ***Estimate the Required Influent Pressure (G32:H35)***, requires the user to estimate the system pressure losses (ΔP_{loss}) and enter the desired permeate stream pressure (P_p). The spreadsheet will then estimate the required influent pressure (P_I) based on the osmotic pressure gradient, the design flux, the water mass transfer coefficient, the estimated system pressure losses and the design permeate pressure.

The flow rates and pressures calculated in this field are intended to provide a starting point for the Long-Term SEBST study, and the concentrate-waste flow rate and influent pressure may need to be adjusted during the course of the run to obtain the desired recovery and permeate flux.

8.4 Field 4: Foulants And Fouling Indices *(J3:K29)*

Exhibit 8-4 shows an example of Field 4 which is used to report the concentrations of various foulants and the values of fouling indices for the feed water prior to pretreatment. Numerous water quality parameters that could constitute a fouling problem are included here, however only those parameters relevant to the water being tested need to be evaluated. Foulants and indices not listed in this field, but which are evaluated as part of the study, should be reported in the blank rows. The information in this field should be used to select appropriate pretreatment to membrane separations in order to minimize fouling.

8.5 Field 5: Pretreatment Used Prior To Membranes *(M3:O24)*

Field 5 is used to report all pretreatment processes used prior to the SEBST test system, and Exhibit 8-5 presents an example of Field 5. All full-scale and pilot-scale pretreatment processes should be listed in this field. The process name should be entered, along with a brief description of the process (e.g., chemical dose, cartridge filter exclusion size, etc.) and the scale of the process (i.e., full-scale or pilot-scale). Detailed design information is not required in this spreadsheet since this design data will be included in the hard-copy *Treatment Study Summary Report* as described in Section 10.0 of this document. The purpose of Field 5 is to associate the pretreatment processes used during the Long-Term SEBST study with the data entered in the spreadsheet.

8.6 Field 6: Membrane Performance Data During Operation With The Test Water *(Q3:BL220)*

Field 6 is used to report the parameters monitored during operation with the pretreated test water, and an example of Field 6 is shown in Exhibit 8-6.

Note: Only one-fifth of the operational data from the total run time (i.e., data from approximately 1320 hours of operation) will be reported in Field 6 of each field-set.

In Field 6, the date, time and cumulative operation time must be reported. The operation time is reported in decimal hours and is defined with respect to the starting date and time of Long-Term SEBST operation with the pretreated test water. Any period of time during which system operation is interrupted (e.g., during a cleaning event) must not be included in the cumulative operation time. Membrane cleaning events should be indicated with an "**X**" in column ***AA*** of this field.

The operating parameters that are reported in Field 6 include the influent temperature and pressure; the concentrate and permeate pressures; and the permeate, concentrate-recycle and concentrate-waste flow rates. The spreadsheet uses these entered values to calculate operating parameters such as the feed flow rate, influent flow rate, cross-flow velocity, recovery, flux, net driving pressure and water mass transfer coefficient. **It is important to enter all measured parameters in the specified units: temperature in °C, pressure in psi and flow rate in gpm.**

The temperature normalized flux is calculated using a generic temperature correction equation (see Equation 8a.18 in Appendix 8a). If a membrane specific temperature correction equation is provided by the manufacturer, it should be used instead of Equation 8a.18. To use a different temperature correction equation, overwrite the existing equation in cells ***AH7:AH220***, making sure that the revised equation references the proper cells. To overwrite an equation in the spreadsheet, the sheet must be Unprotected, and the cells containing the equation must be unLocked as described in Section 3.3.

Field 6 is also used to report the feed, permeate and concentrate water quality parameters that are monitored with time: pH and TDS (and UV_{254} / TOC if measured). The TDS and pH must be monitored every time the system flows and pressures are monitored; however, UV_{254} and/or TOC can be monitored at any desired frequency, if at all. For measured parameters, the spreadsheet will calculate the feed rejection (R_F), the calculated concentrate concentration ($C_{C(calc)}$), the bulk concentration (C_B) and the bulk rejection (R_B). When both permeate and concentrate water quality parameters are analyzed for the same sampling event, the mass balance closure error ($Error_{MB}$) is calculated.

8.7 Fields 7 Through 12: Permeate, Feed, Concentrate And Blended Water Quality For Week ___ *(BN3:BW76; BY3:CH76; CJ3:CS76; CU3:DD76; DF3:DO76; DQ3:DZ76)*

Fields 7 through 12 are used to report the permeate, feed and concentrate water quality for every other week of Long-Term SEBST operation, and an example of Field 7 is shown in Exhibit 8-7. Fields 7 through 12 appear in all five of the LT-SEBST field-sets and are used to report data from different weeks of Long-Term SEBST operation. Table 8-3 summarizes the field-set/field designations (i.e. Field 1-7 through Field 5-12) that are used to report the results from each set of bi-weekly water quality analyses.

Field Designation	**Week of Long-Term SEBST Operation**				
	Field-Set 1	***Field-Set 2***	***Field-Set 3***	***Field-Set 4***	***Field-Set 5***

7	Week 2	Week 12	Week 22	Week 32	Week 42
8	Week 4	Week 14	Week 24	Week 34	Week 44
9	Week 6	Week 16	Week 26	Week 36	Week 46
10	Week 8	Week 18	Week 28	Week 38	Week 48
11	Week 10	Week 20	Week 30	Week 40	Week 50
12	Week 10, dup[1]	Week 20, dup	Week 30, dup	Week 40, dup	Week 50, dup

1: dup indicates results from a duplicate analyses of the water quality parameters for the designated week are reported in the specified field.

Table 8-3 Field Designations For The Bi-Weekly Water Quality Data Reported In Each LT-SEBST Field-Set

The date, time and operation time at which each sample is collected must be entered in Field 7. The following water quality parameters are to be analyzed and reported for the permeate and feed samples: pH, temperature, alkalinity, TDS, total hardness, calcium hardness, turbidity, ammonia, TOC, UV_{254}, bromide, SDS-chlorine demand, SDS-TOX, SDS-THM4 and SDS-HAA6[1].

The following concentrate water quality parameters must be reported in Field 7: pH, temperature, alkalinity, TDS, total hardness, calcium hardness, turbidity, ammonia, TOC and UV_{254}. The spreadsheet will automatically calculate the mass balance closure error for these water quality parameters with the exception of pH and temperature.

The spreadsheet also calculates the concentrate concentration, the feed rejection, the bulk concentration and the bulk rejection, as well as the SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

In order to calculate the mass balance closure error, bulk concentration and bulk rejection, the following operating parameters must be entered in cells ***BP5:BP7*** of Field 7: the recovery, feed flow rate and influent flow rate. These operating parameters must reflect operation of the system during the time at which the permeate and concentrate samples are collected. The recovery must be expressed as a decimal fraction and the flow rates must be expressed in gpm.

The third block of Field 7, ***Blending Calculation for D-DBP MCLs (BN52:BT76)***, calculates the permeate flow to total product flow ratio (i.e., blend ratio) that can be used to meet the Stage 1 and proposed Stage 2 D-DBP MCLs with a 10% factor of safety. The spreadsheet uses the permeate and feed concentrations entered in the second block of Field 7 ***(BN9:BW50)*** to calculate the permeate to total product flow ratio (Q_p/Q_T) required to achieve

[1]Only six HAA species are required, but the additional three HAA species (TBAA, CDBAA and DCBAA) should be reported if measured.

the D-DBP MCLs with a 10% factor of safety. For Stage 1, 90% of the D-DBP MCLs are 72 μg/L for THM4 and 54 μg/L for HAA5. For Stage 2, 90% of the D-DBP MCLs are 36 μg/L for THM4 and 27 μg/L for HAA5. The blend ratio is used to calculate the water quality of the feed/permeate blend. Blended water qualities are indicated by the subscript "b" and are calculated for SDS-THM4, SDS-HAA5, SDS-TOX, SDS-CD, TOC, UV_{254}, bromide, alkalinity, total hardness and calcium hardness.

In some cases, the blending calculations are meaningless. If the permeate concentration does not meet 90% of the DBP MCL prior to blending, then the blend ratio will be greater than 100% indicating that blending is not feasible. If the feed concentration meets 90% of the DBP MCL prior to blending then nanofiltration is not required to meet the MCL and the blend ratio will be negative. In both of these cases, the spreadsheet will report "NA" for the blended water quality parameters since the calculated values have no physical significance.

When the blending calculations are relevant, the user must compare the blend ratios calculated for THM4 and HAA5 since the higher blend ratio is the minimum ratio that will meet both MCLs with a 10% factor of safety. For example, in Exhibit 8-7 the THM4 MCL controls the blend ratio for both Stage 1 and Stage 2.

8.8 Field 13: Membrane Cost Parameters *(EB3:EC20)*

Field 13 is used to report the utility-specific cost parameters that are used to generate cost estimates for the use of membrane technology, and an example of Field 13 is shown in Exhibit 8-8. Example cost parameters are listed in Exhibit 8-8, but it is important to report cost parameters specific to the utility and not default or example values.

	A	B
3	**Field E-1: PWS And Treatment Plant Data**	
4		
5	PWS Name	Anytown Public Works
6	Public Water System Identification Number	OH1234567
7	Water Industry Data Base Number (*optional*)	######
8		
9	Official ICR Contact Person	Mr. Any Body
10	Mailing Address	#### Street
11		City, State Zip code
12	Phone Number	(###) ###-####
13	FAX Number	(###) ###-####
14	E-Mail Address (*optional*)	last.first@wtp.com
15		
16	Technical ICR Contact Person	Ms. Some One
17	Mailing Address	#### Street
18		City, State Zip code
19	Phone Number	(###) ###-####
20	FAX Number	(###) ###-####
21	E-Mail Address (*optional*)	last.first@wtp.com
22		
23	Plant Name	East WTP
24	Treatment Plant Category	CONV
25	Process Train Name	Conventional train
26	ICR Treatment Plant Identification Number	###
27	PWSID Number of Plant (*if assigned*)	Not assigned
28	Historical Minimum Water Temperature (^{o}C)	4.0
29	Historical Average Water Temperature (^{o}C)	18.0
30	State Approved Plant Capacity (MGD)	100.0
31		
32	**Exhibit 8-1 Example Of Field 1 For The Long-Term SEBST Data Sheet**	

	D	E
3	**Field E-2: Manufacturer Reported Membrane Characteristics[1]**	
4	***General Information***	
5	Membrane manufacturer	Company Name
6	Membrane trade name	NFPA-200
7	Membrane element model number	NFPA-200 4040
8	Molecular weight cutoff (Daltons)	200
9	Membrane material (e.g., PVD, polyamide, etc.)	polyamide
10	Membrane construction (e.g., thin-film composite)	thin-film composite
11	Membrane hydrophobicity	hydrophilic
12	Membrane charge (e.g., negative, highly negative, neutral, etc.)	highly negatively charged
13		
14	***Design Parameters***	
15	Element size (e.g., 2.5" x 40", 4" x 40", etc.)	4" x 40"
16	Active membrane area of membrane element used, A (ft^2)	70.0
17	Design flux, F_W (gfd)	15.0
18	Net driving pressure at the design flux, NDP (psi)	80.0
19	Water mass transfer coefficient, MTC_W (gfd/psi)	0.188
20	Temperature at which the MTC_W was determined, T^oC (^oC)	25.0
21	Maximum flow rate to the element, $Q_{I,\ max}$ (gpm)	16.0
22	Minimum flow rate to the element, $Q_{I,\ min}$ (gpm)	4.0
23	Total width of all membrane envelopes in the element, w (ft)	12.0
24	Feed spacer thickness, T (ft)	0.0025
25	Active membrane area of an equivalent 8" x 40" element (ft^2)	315.0
26	Purchase price for an equivalent 8" x 40 " element ($)	1000.00
27		
28	***Additional Information***	
29	Design cross-flow velocity (fps)	0.257
30	Required influent flow to permeate flow rate ratio, Q_I:Q_p	6:1
31	Maximum element recovery (%)	16
32	Variability of design flux (%)	15
33	Rejection of reference solute and conditions of test	90% rejection of a 2000 mg/L
34	(e.g., solute type and concentration)	$MgSO_4$ solution
35	Variability of rejection of reference solute (%)	1
36	Standard testing recovery (%)	15
37	Standard testing pH	7
38	Acceptable range of operating pressures	0 - 250
39	Acceptable range of operating pH values	3 - 9
40	Typical pressure drop across a single element (psi)	5
41	Maximum permissible SDI	5
42	Maximum permissible turbidity (ntu)	Not reported
43	Chlorine/oxidant tolerance (e.g., < 0.1 mg/L for extended use, etc.)	1.0 mg/L maximum
44	1: All of the information requested in this field may not be available, but values for all of the ***Design***	
45	***Parameters*** must be entered in cells E15:E26, since these parameters are used in calculations.	
46		
47	**Exhibit 8-2 Example Of Field 2 For The Long-Term SEBST Data Sheet**	

	G	H
3	**Field E-3: SEBST Design Parameters**	
4	***Calculate Temperature Normalized MTC_W***	
5	Average yearly temperature of feed water, Tavg°C (°C)	18.0
6	Temperature normalized MTC_W, MTC_W(Tavg°C) (gfd/psi)	0.152
7		
8	***Calculate System Flow Rates***[1]	
9	Design recovery, R (decimal)	0.75
10	Design flux, F_W (gfd)	15.0
11	Permeate flow rate, Q_p (gpm)	0.73
12	Feed flow rate, Q_F (gpm)	0.97
13	Concentrate-waste flow rate, Q_W (gpm)	0.24
14	Minimum influent flow rate, $Q_{I, min}$ (gpm)	4.0
15	Maximum influent flow rate, $Q_{I, max}$ (gpm)	16.0
16	Design influent flow rate[2], Q_I (gpm)	6.0
17	Design recycle flow rate, Q_R (gpm)	5.03
18	Recycle ratio, r	5.17
19	1: Flow rates and pressures may need to be adjusted in order to obtain	
20	the desired operating conditions.	
21	2: The design influent flow rate must be within the range established by the	
22	minimum and maximum influent flow rates (i.e., cells H14 and H15).	
23		
24	***Estimate the Osmotic Pressure Gradient***	
25	Manufacturer reported TDS rejection, Rej_{TDS} (decimal)	0.70
26	Feed TDS, TDS_F (mg/L)	150.0
27	Waste TDS, TDS_W (mg/L)	329.6
28	Permeate TDS, TDS_p (mg/L)	90.1
29	Influent TDS, TDS_I (mg/L)	300.5
30	Osmotic pressure gradient, $\Delta\pi$ (psi)	2.2
31		
32	***Estimate the Required Influent Pressure***	
33	Estimated system pressure losses, ΔP_{loss} (psi)	8.0
34	Design permeate pressure, P_p (psi)	4.0
35	Required influent pressure, P_I (psi)	112.6
36		
37	**Exhibit 8-3 Example Of Field 3 For The Long-Term SEBST Data Sheet**	

	J	K
3	**Field E-4: Foulants And Fouling Indices[1]**	
4	***Parameters Evaluated Prior to Pretreatment***	
5	Alkalinity (mg/L as $CaCO_3$)	40
6	Calcium Hardness (mg/L as $CaCO_3$)	79
7	LSI	1.4
8	Dissolved iron (mg/L)	15
9	Total iron (mg/L)	17
10	Dissolved aluminum (mg/L)	
11	Total aluminum (mg/L)	
12	Fluoride (mg/L)	
13	Phosphate (mg/L)	
14	Sulfate (mg/L)	
15	Calcium (mg/L)	
16	Barium (mg/L)	
17	Strontium (mg/L)	
18	Reactive silica (mg/L as SiO_2)	
19	Turbidity (ntu)	5
20	SDI	4
21	MFI	
22	MPFI	
23		
24		
25		
26		
27		
28	1: Only those foulants and fouling indices relevant to the water being tested need to	
29	be evaluated. Additional foulants and indices can be listed in the blank rows.	
30		
31	**Exhibit 8-4 Example Of Field 4 For The Long-Term SEBST Data Sheet**	

	M	N	O
3	**Field E-5: Pretreatment Used Prior To Membranes**[1]		
4			
5	**Process**	**Description**	**Scale**
6	Coagulation	50 $\pm$ 15 mg/L alum	Full-scale
7	Flocculation	2-stage	Full-scale
8	Sedimentation	tube settler	Full-scale
9	Dual media filtration	sand / anthracite	Full-scale
10	Cartridge filtration	2 μm exclusion size	Pilot-scale
11	Sulfuric acid addition	pH = 6.0	Pilot-scale
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22	1: Design information, similar to that shown in Tables 6c and 6d of the ICR rule, must be included in		
23	the hard-copy *Treatment Study Summary Report* (see Section 10.0). The purpose of this table		
24	is to list the pretreatment processes used in this particular Long-Term SEBST run.		
25			
26	**Exhibit 8-5 Example Of Field 5 For The Long-Term SEBST Data Sheet**		

Field E-6: Membrane Performance Data During Operation With The Test Water

	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
5	Date	Time	Operation time	Influent	P_I	P_C	P_P	Q_R	Q_p	Q_W	Cleaning Event	Q_F	Q_I	v_c	Recovery	Recycle	F_W (T^oC)	F_W ($Tavg^oC$)	$\Delta\pi$	NDP	MTC_W ($Tavg^oC$)
6	MM/DD/YY	hh:mm	hh.hh	Temp. (^oC)	(psi)	(psi)	(psi)	(gpm)	(gpm)	(gpm)	Indicate with "**X**"	(gpm)	(gpm)	(fps)	(decimal)	ratio	(gfd)	(gfd)	(psi)	(psi)	(gfd/psi)
7	4/1/96	8:00	0.00	18.0	113.0	105.0	4.0	4.90	0.74	0.23		0.97	5.87	0.408	0.76	5.05	15.22	15.22	3.2	101.8	0.150
8	4/2/96	8:00	24.00	18.1	114.0	105.0	4.0	5.00	0.74	0.24		0.98	5.98	0.417	0.76	5.10	15.22	15.18	3.2	102.3	0.148
9	4/3/96	8:00	48.00	18.0	115.0	105.0	4.0	5.00	0.75	0.24		0.99	5.99	0.417	0.76	5.05	15.43	15.43	3.3	102.7	0.150
10	4/4/96	8:00	72.00	18.2	115.0	105.0	4.0	4.80	0.75	0.24		0.99	5.79	0.402	0.76	4.85	15.43	15.34	3.3	102.7	0.149
11	4/5/96	8:00	96.00	18.2	116.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.54	3.4	103.1	0.151
12	4/6/96	8:00	120.00	18.3	116.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.50	3.2	103.3	0.150
13	4/7/96	8:00	144.00	18.3	116.0	105.0	4.0	5.10	0.75	0.25		1.00	6.10	0.425	0.75	5.10	15.43	15.29	3.2	103.3	0.148
14	4/8/96	8:00	168.00	18.3	116.0	105.0	4.0	5.00	0.73	0.26		0.99	5.99	0.418	0.74	5.05	15.02	14.88	3.1	103.4	0.144
15	4/9/96	8:00	192.00	18.4	117.0	105.0	4.0	4.90	0.74	0.24		0.98	5.88	0.409	0.76	5.00	15.22	15.04	3.3	103.7	0.145
16	4/10/96	8:00	216.00	18.3	117.0	105.0	4.0	5.10	0.74	0.24		0.98	6.08	0.424	0.76	5.20	15.22	15.09	3.1	103.9	0.145
17	4/11/96	8:00	240.00	18.3	117.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.29	3.2	103.9	0.147
18	4/12/96	8:00	264.00	18.2	117.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.34	3.0	104.0	0.147
19	4/13/96	8:00	288.00	18.1	117.0	105.0	4.0	4.90	0.75	0.23		0.98	5.88	0.409	0.77	5.00	15.43	15.38	3.4	103.6	0.148
20	4/14/96	8:00	312.00	18.0	117.0	105.0	4.0	5.00	0.76	0.25		1.01	6.01	0.418	0.75	4.95	15.63	15.63	3.1	103.9	0.151
21	4/15/96	8:00	336.00	18.1	118.0	105.0	4.0	4.90	0.75	0.25		1.00	5.90	0.410	0.75	4.90	15.43	15.38	3.2	104.3	0.147
22	4/16/96	8:00	360.00	18.0	118.0	105.0	4.0	5.00	0.74	0.23		0.97	5.97	0.416	0.76	5.15	15.22	15.22	3.5	104.0	0.146
23	4/17/96	8:00	384.00	18.2	118.0	105.0	4.0	5.00	0.74	0.24		0.98	5.98	0.417	0.76	5.10	15.22	15.13	3.3	104.2	0.145
24	4/18/96	8:00	408.00	18.2	118.0	105.0	4.0	4.80	0.75	0.24		0.99	5.79	0.402	0.76	4.85	15.43	15.34	3.4	104.1	0.147
25	4/19/96	8:00	432.00	18.3	119.0	105.0	4.0	5.10	0.75	0.24		0.99	6.09	0.424	0.76	5.15	15.43	15.29	3.5	104.5	0.146
26	4/20/96	8:00	456.00	18.3	119.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.50	3.4	104.6	0.148
27	4/21/96	8:00	480.00	18.3	119.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.50	3.2	104.8	0.148
28	4/22/96	8:00	504.00	18.4	119.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.25	3.3	104.7	0.146
29	4/23/96	8:00	528.00	18.3	119.0	105.0	4.0	4.90	0.73	0.26		0.99	5.89	0.410	0.74	4.95	15.02	14.88	2.9	105.1	0.142
30	4/24/96	8:00	552.00	18.3	119.0	105.0	4.0	5.10	0.74	0.24		0.98	6.08	0.424	0.76	5.20	15.22	15.09	3.3	104.7	0.144
31	4/25/96	8:00	576.00	18.2	119.0	105.0	4.0	5.00	0.74	0.24		0.98	5.98	0.417	0.76	5.10	15.22	15.13	3.2	104.8	0.144
32	4/26/96	8:00	600.00	18.1	120.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.38	3.2	105.3	0.146
33	4/27/96	8:00	624.00	18.0	120.0	105.0	4.0	4.90	0.75	0.25		1.00	5.90	0.410	0.75	4.90	15.43	15.43	3.3	105.2	0.147
34	4/28/96	8:00	648.00	18.1	120.0	105.0	4.0	5.00	0.75	0.23		0.98	5.98	0.416	0.77	5.10	15.43	15.38	3.4	105.1	0.146
35	4/29/96	8:00	672.00	18.0	120.0	105.0	4.0	4.90	0.76	0.25		1.01	5.91	0.411	0.75	4.85	15.63	15.63	3.2	105.3	0.148
36	4/30/96	8:00	696.00	18.2	120.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.34	3.3	105.2	0.146
37	5/1/96	8:00	720.00	18.2	121.0	105.0	4.0	5.00	0.74	0.23		0.97	5.97	0.416	0.76	5.15	15.22	15.13	3.4	105.6	0.143
38	5/2/96	8:00	744.00	18.3	120.0	105.0	4.0	4.80	0.74	0.24		0.98	5.78	0.402	0.76	4.90	15.22	15.09	3.1	105.4	0.143
39	5/3/96	8:00	768.00	18.3	121.0	105.0	4.0	5.10	0.75	0.24		0.99	6.09	0.424	0.76	5.15	15.43	15.29	3.3	105.7	0.145
40	5/4/96	8:00	792.00	18.3	121.0	105.0	4.0	5.10	0.75	0.24		0.99	6.09	0.424	0.76	5.15	15.43	15.29	3.2	105.8	0.145
41	5/5/96	8:00	816.00	18.4	121.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.45	3.3	105.7	0.146
42	5/6/96	8:00	840.00	18.3	121.0	105.0	4.0	5.00	0.76	0.25		1.01	6.01	0.418	0.75	4.95	15.63	15.50	3.3	105.7	0.147
43	5/7/96	8:00	864.00	18.3	121.0	105.0	4.0	4.90	0.75	0.25		1.00	5.90	0.410	0.75	4.90	15.43	15.29	3.2	105.8	0.145
44	5/8/96	8:00	888.00	18.2	122.0	105.0	4.0	5.10	0.73	0.26		0.99	6.09	0.425	0.74	5.15	15.02	14.93	3.2	106.3	0.140
45	5/9/96	8:00	912.00	18.1	122.0	105.0	4.0	5.00	0.74	0.24	**X**	0.98	5.98	0.417	0.76	5.10	15.22	15.18	3.2	106.3	0.143
46	5/10/96	8:00	936.00	18.2	112.0	105.0	4.0	5.00	0.74	0.24		0.98	5.98	0.417	0.76	5.10	15.22	15.13	3.2	101.3	0.149
47	5/11/96	8:00	960.00	18.2	114.0	105.0	4.0	4.90	0.75	0.25		1.00	5.90	0.410	0.75	4.90	15.43	15.34	3.2	102.3	0.150
48	5/12/96	8:00	984.00	18.4	114.0	105.0	4.0	5.00	0.75	0.25		1.00	6.00	0.418	0.75	5.00	15.43	15.25	3.3	102.2	0.149
49	5/13/96	8:00	1008.00	18.3	114.0	105.0	4.0	5.00	0.75	0.23		0.98	5.98	0.416	0.77	5.10	15.43	15.29	3.4	102.1	0.150
50	5/14/96	8:00	1032.00	18.2	115.0	105.0	4.0	5.10	0.76	0.25		1.01	6.11	0.426	0.75	5.05	15.63	15.54	3.4	102.6	0.151

Exhibit 8-6 Example Of Field 6 For The Long-Term SEBST Data Sheet (page 1 of 2)

	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL
3	**Field E-6: Membrane Performance Data During Operation With The Test Water (continued)**																										
4																											
5	pH			TDS (mg/L)								UV_{254} (cm^{-1}), *Optional*								TOC (mg/L), *Optional*							
6	pH_p	pH_F	pH_C	TDS_p	TDS_F	TDS_C	$TDS_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	TDS_B	R_B (%)	UV_p	UV_F	UV_C	$UV_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	UV_B	R_B (%)	TOC_p	TOC_F	TOC_C	$TOC_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	TOC_B	R_B (%)
7	5.49	6.05	6.34	65.00	147.00	413.00	410.83	0.53	55.8	389.03	83.3	0.022	0.331		1.325		93.4	1.243	98.2	0.94	7.95		30.50		88.2	28.64	96.7
8	5.50	6.10	6.35	67.00	151.00	415.00	410.00	1.20	55.6	388.78	82.8																
9	5.61	6.11	6.30	65.50	150.00	412.00	414.06	-0.50	56.3	392.24	83.3																
10	5.45	6.03	6.30	64.00	150.00	411.00	418.75	-1.89	57.3	395.77	83.8	0.027	0.331	1.260	1.281	-1.67	91.8	1.200	97.7	1.04	8.05	28.70	29.96	-4.38	87.1	28.08	96.3
11	5.50	6.00	6.38	63.00	153.00	415.00	426.60	-2.80	58.8	403.99	84.4																
12	5.53	6.00	6.22	64.50	149.00	416.00	405.88	2.43	56.7	384.65	83.2																
13	5.55	6.02	6.24	65.00	149.00	418.00	401.00	4.07	56.4	380.34	82.9	0.024	0.331		1.252		92.7	1.177	98.0	0.96	7.96		28.96		87.9	27.24	96.5
14	5.50	6.03	6.20	65.00	152.00	415.00	396.27	4.51	57.2	376.08	82.7																
15	5.67	6.03	6.20	66.00	153.00	417.00	421.25	-1.02	56.9	398.90	83.5																
16	5.50	6.05	6.45	67.50	148.00	418.00	396.21	5.21	54.4	376.20	82.1																
17	5.44	6.00	6.44	66.00	150.00	416.00	402.00	3.37	56.0	381.00	82.7	0.029	0.333	1.250	1.245	0.40	91.3	1.169	97.5	1.04	8.07	28.60	29.16	-1.96	87.1	27.40	96.2
18	5.56	6.00	6.50	68.00	147.00	413.00	384.00	7.02	53.7	364.25	81.3	0.028	0.331		1.240		91.5	1.164	97.6	1.08	7.99		28.72		86.5	26.99	96.0
19	5.58	6.12	6.38	67.00	151.00	415.00	424.91	-2.39	55.6	402.09	83.3																
20	5.51	6.08	6.33	67.00	150.00	412.00	402.32	2.35	55.3	381.12	82.4																
21	5.53	5.98	6.30	65.00	150.00	411.00	405.00	1.46	56.7	383.39	83.0																
22	5.52	6.00	6.30	65.00	153.00	415.00	436.13	-5.09	57.5	413.13	84.3	0.027	0.331		1.309		91.8	1.230	97.8	1.04	8.05		30.60		87.1	28.77	96.4
23	5.52	6.00	6.34	62.00	149.00	416.00	417.25	-0.30	58.4	395.27	84.3																
24	5.50	5.99	6.34	61.00	149.00	418.00	424.00	-1.44	59.1	400.49	84.8	0.024	0.332		1.295		92.8	1.212	98.0	0.92	7.92		29.80		88.4	27.92	96.7
25	5.50	6.01	6.30	61.00	152.00	415.00	436.38	-5.15	59.9	413.26	85.2																
26	5.58	6.04	6.30	62.00	153.00	417.00	429.64	-3.03	59.5	406.78	84.8	0.026	0.328	1.200	1.246	-3.84	92.1	1.170	97.8	0.96	8.00	28.00	29.40	-5.01	88.0	27.63	96.5
27	5.61	6.03	6.41	63.00	148.00	418.00	406.40	2.78	57.4	385.04	83.6																
28	5.64	6.00	6.44	63.00	150.00	416.00	411.00	1.20	58.0	389.25	83.8																
29	5.56	6.00	6.40	65.00	147.00	413.00	377.23	8.66	55.8	357.88	81.8																
30	5.50	6.03	6.30	66.00	151.00	415.00	413.08	0.46	56.3	391.96	83.2	0.028	0.331		1.265		91.5	1.190	97.6	1.08	7.99		29.30		86.5	27.58	96.1
31	5.50	6.00	6.25	66.00	150.00	412.00	409.00	0.73	56.0	387.78	83.0																
32	5.21	6.01	6.28	65.00	150.00	411.00	405.00	1.46	56.7	383.75	83.1																
33	5.38	6.03	6.30	64.00	153.00	415.00	420.00	-1.20	58.2	397.37	83.9	0.028	0.329		1.232		91.5	1.155	97.6	0.98	8.00		29.06		87.8	27.28	96.4
34	5.34	6.11	6.30	64.00	149.00	416.00	426.17	-2.45	57.0	403.46	84.1																
35	5.67	6.00	6.24	65.00	149.00	418.00	404.36	3.26	56.4	382.54	83.0																
36	5.54	6.00	6.30	63.00	152.00	415.00	419.00	-0.96	58.6	396.75	84.1	0.024	0.332		1.256		92.8	1.179	98.0	0.92	7.92		28.92		88.4	27.17	96.6
37	5.50	6.03	6.24	67.00	153.00	417.00	429.70	-3.04	56.2	407.22	83.5	0.024	0.331	1.250	1.319	-5.50	92.7	1.238	98.1	0.96	7.96	28.20	30.48	-8.09	87.9	28.65	96.6
38	5.50	5.98	6.30	67.00	148.00	418.00	397.75	4.84	54.7	376.58	82.2																
39	5.54	5.97	6.29	64.50	150.00	416.00	417.19	-0.29	57.0	395.47	83.7	0.028	0.327		1.261		91.4	1.185	97.6	1.00	8.03		30.00		87.5	28.21	96.5
40	5.50	6.00	6.30	65.00	147.00	413.00	403.25	2.36	55.8	382.42	83.0	0.030	0.331		1.272		90.9	1.195	97.5	1.00	8.02		29.96		87.5	28.17	96.5
41	5.50	6.00	6.27	65.00	151.00	415.00	412.44	0.62	57.0	390.83	83.4																
42	5.57	6.09	6.30	62.00	150.00	412.00	417.52	-1.34	58.7	395.04	84.3																
43	5.48	6.03	6.24	63.50	150.00	411.00	409.50	0.36	57.7	387.51	83.6																
44	5.49	6.05	6.34	64.00	153.00	415.00	402.88	2.92	58.2	382.57	83.3	0.025	0.333	1.255	1.198	4.56	92.5	1.127	97.8	1.04	8.05	28.70	27.73	3.37	87.1	26.13	96.0
45	5.50	6.10	6.35	64.50	149.00	416.00	409.54	1.55	56.7	388.19	83.4																
46	5.61	6.11	6.30	66.00	149.00	418.00	404.92	3.13	55.7	383.95	82.8																
47	5.45	6.03	6.30	67.00	152.00	415.00	407.00	1.93	55.9	385.39	82.6																
48	5.50	6.00	6.38	66.00	153.00	417.00	414.00	0.72	56.9	392.25	83.2	0.028	0.331	1.250	1.240	0.80	91.5	1.164	97.6	0.96	8.00	28.00	29.12	-4.00	88.0	27.36	96.5
49	5.50	6.00	6.27	63.00	148.00	418.00	425.17	-1.72	57.4	402.46	84.3																
50	5.57	6.09	6.30	61.00	150.00	416.00	420.56	-1.10	59.3	398.20	84.7	0.030	0.331		1.246		90.9	1.170	97.4	1.00	8.02		29.36		87.5	27.60	96.4
51																											
52	**Exhibit 8-6 Example Of Field 6 For The Long-Term SEBST Data Sheet (page 2 of 2)**																										

Field E-7: Permeate, Feed, Concentrate And Blended Water Quality For Week 2

Operating Parameters During Sample Collection

Recovery during sample collection (decimal)	0.75
Feed flow rate during sample collection (gpm)	1.00
Influent flow rate during sample collection (gpm)	6.00

Permeate, Feed and Concentrate Water Quality

Parameter	Units	C_p-2	C_F-2	C_C-2	$C_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	C_B	R_B (%)
Sampling date	MM/DD/YY	4/12/96	4/12/96	4/12/96	---	---	---	---	---
Sampling time	hh:mm	8:00	8:00	8:00	---	---	---	---	---
Operation time	hh.hh	264.00	264.00	264.00	---	---	---	---	---
pH	---	5.53	5.98	6.30	---	---	---	---	---
Temperature	^oC	18.1	18.1	18.2	---	---	---	---	---
Alkalinity	mg/L as $CaCO_3$	35.0	75.0	202.0	195.0	3.47	53.3	185.0	81.1
Total dissolved solids	mg/L	65.0	150.0	411.0	405.0	1.46	56.7	383.8	83.1
Total hardness	mg/L as $CaCO_3$	108.0	320.0	952.0	956.0	-0.42	66.3	903.0	88.0
Calcium hardness	mg/L as $CaCO_3$	97.0	291.0	860.0	873.0	-1.51	66.7	824.5	88.2
Turbidity	ntu	0.10	0.80	3.00	2.90	3.33	87.5	2.73	96.3
Ammonia	mg NH_3-N / L	1.20	4.80	15.80	15.60	1.27	75.0	14.70	91.8
Total organic carbon	mg/L	0.98	8.00	29.50	29.06	1.49	87.8	27.31	96.4
UV_{254}	cm^{-1}	0.028	0.329	1.250	1.232	1.44	91.5	1.15675	97.6
SUVA	L/(mg*m)	2.86	4.11	4.24	---	---	---	---	---
Bromide	µg/L	151.0	250.0	---	547.0	---	39.6	522.3	71.1
SDS-Cl_2 dose	mg/L	1.80	12.00	---	---	---	---	---	---
SDS-Free Cl_2 residual	mg/L	0.90	0.90	---	---	---	---	---	---
SDS-Cl_2 demand	mg/L	0.90	11.10	---	41.70	---	91.9	39.15	97.7
SDS-Chlorination temp.	^oC	18.8	18.8	---	---	---	---	---	---
SDS-Chlorination pH	---	7.86	7.88	---	---	---	---	---	---
SDS-Incubation time	hours	84.5	84.5	---	---	---	---	---	---
SDS-TOX	µg Cl^-/L	52.00	980.00	---	3764.00	---	94.7	3532.00	98.5
SDS-*CHCl3*	µg/L	12.80	162.00	---	609.60	---	92.1	572.30	97.8
SDS-*BDCM*	µg/L	10.30	48.00	---	161.10	---	78.5	151.68	93.2
SDS-*DBCM*	µg/L	9.60	10.00	---	11.20	---	4.0	11.10	13.5
SDS-*CHBr3*	µg/L	0.87	0.45	---	-0.81	---	-93.3	-0.71	223.4
SDS-THM4	µg/L	33.57	220.45	---	781.09	---	84.8	734.37	95.4
SDS-*MCAA**	µg/L	BMRL	4.10	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
SDS-*DCAA**	µg/L	5.63	30.50	---	105.11	---	81.5	98.89	94.3
SDS-*TCAA**	µg/L	8.25	58.90	---	210.85	---	86.0	198.19	95.8
SDS-*MBAA**	µg/L	BMRL	0.97	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
SDS-*DBAA**	µg/L	4.23	2.86	---	-1.25	---	-47.9	-0.91	566.1
SDS-*BCAA**	µg/L	8.68	21.30	---	59.16	---	59.2	56.01	84.5
SDS-*TBAA*	µg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
SDS-*CDBAA*	µg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
SDS-*DCBAA*	µg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
SDS-HAA5	µg/L	18.11	97.33	---	334.99	---	81.4	315.19	94.3
SDS-HAA6	µg/L	26.79	118.63	---	394.15	---	77.4	371.19	92.8

BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

Blending Calculations For D-DBP MCLs

THM4 Controls

	Stage 1	Stage 2
Q_p/Q_T (THM4), %	79.4	98.7
SDS-$THM4_b$, µg/L	72.00	36.00
SDS-$HAA5_b$, µg/L	34.40	19.14
SDS-TOX_b, µg Cl^-/L	242.83	64.07
SDS-CD_b, mg/L	3.00	1.03
TOC_b, mg/L	2.42	1.07
$UV_{254\ b}$, cm^{-1}	0.090	0.032
$Bromide_b$, µg/L	171.4	152.3
Alk_b, mg/L $CaCO_3$	43.2	35.5
T-Hd_b, mg/L $CaCO_3$	151.6	110.8
Ca-Hd_b, mg/L $CaCO_3$	136.9	99.5

HAA5 Controls

	Stage 1	Stage 2
Q_p/Q_T (HAA5), %	54.7	88.8
SDS-$THM4_b$, µg/L	118.23	54.54
SDS-$HAA5_b$, µg/L	54.00	27.00
SDS-TOX_b, µg Cl^-/L	472.42	156.14
SDS-CD_b, mg/L	5.52	2.04
TOC_b, mg/L	4.16	1.77
$UV_{254\ b}$, cm^{-1}	0.164	0.062
$Bromide_b$, µg/L	195.9	162.1
Alk_b, mg/L $CaCO_3$	53.1	39.5
T-Hd_b, mg/L $CaCO_3$	204.0	131.8
Ca-Hd_b, mg/L $CaCO_3$	184.9	118.8

Notes:
This field uses the feed and permeate water quality parameters entered above to determine the percentage of total flow that must be treated by the membrane process to meet the Stage 1 and proposed Stage 2 DBP MCLs.
A 10% factor of safety has been applied all the MCLs. i.e., MCLs for Stage 1 are 72 / 54 µg/L and Stage 2 are 36 / 27 µg/L for THM4 and HAA5.
Since either THM4 or HAA5 can control the allowable blend ratio, the blend ratio is calculated for both parameters.
The maximum (Q_p/Q_T) ratio controls the design.
Q_p/Q_T (THM4) is the permeate to total flow ratio for the case where THM4 controls the blend ratio.
Q_p/Q_T (HAA5) is the permeate to total flow ratio for the case where HAA5 controls the blend ratio.
The subscript "b" refers to the blended water quality for a given blend ratio.
If the permeate quality does not meet the MCL prior to blending, then these calculations are meaningless for that MCL.
If the feed water quality meets the MCL, then a negative ratio will be calculated for that MCL.

Exhibit 8-7 Example Of Field 7 For The Long-Term SEBST Data Sheet

	EB	EC
3	**Field E-13: Membrane Cost Parameters**	
4	***General Cost Parameters***	
5	**Cost Parameter**	**Parameter value**
6	Capital Recovery Interest Rate (%)	10
7	Capital Recovery Period (years)	20
8	Overhead & Profit Factor (% of construction costs)	5
9	Special Sitework Factor (% of construction costs)	5
10	Construction Contingencies (% of construction costs)	10
11	Engineering Fee Factor (% of construction costs)	10
12	1998 ENR Construction Cost Index (CCI base year 1913)	####
13	1998 Producers Price Index (PPI base year 1967 = 100)	###
14	Labor Rate + Fringe ($/work-hour)	15
15	Labor Overhead Factor (% of labor)	10
16	Electric Rate ($/kW-h)	0.086
17	Fuel Oil Rate ($/gal)	0.89
18	Natural Gas Rate ($/ft^3)	0.0055
19	Current Process Water Rate ($/1000 gal)	0.35
20	Modifications to Existing Plant (% of construction costs)	5
21		
22	**Exhibit 8-8 Example Of Field 13 For The Long-Term SEBST Data Sheet**	

Appendix 8a: Membrane LT-SEBST Equations And Nomenclature

Nomenclature

A	Active membrane area of the full-scale element used in the SEBST **(ft^2)**
BCAA	Bromochloroacetic acid **(μg/L)**
BDCAA	Bromodichloroacetic acid **(μg/L)**
BDCM	Bromodichloromethane **(μg/L)**
BMRL	Below minimum reporting level
$\mathbf{C_b}$	Concentration of a blended sample (i.e., feed:permeate blend)
$\mathbf{C_B}$	Concentration in bulk solution
$\mathbf{C_C}$	Concentration in the concentrate stream (i.e., waste and recycle streams)
$\mathbf{C_{C(calc)}}$	Concentrate concentration based on a mass balance calculation
$\mathbf{C_F}$	Concentration in the feed stream
$\mathbf{C_p}$	Concentration in the permeate stream
$\mathbf{C_{TG}}$	Treatment goal concentration (e.g., 72μg/L for 90% Stage 1 THM4 MCL)
CHBr3	Bromoform **(μg/L)**
CHCl3	Chloroform **(μg/L)**
DBAA	Dibromoacetic acid **(μg/L)**
DBCAA	Dibromochloroacetic acid **(μg/L)**
DBCM	Dibromochloromethane **(μg/L)**
DCAA	Dichloroacetic acid **(μg/L)**
$\mathbf{Error_{MB}}$	Mass balance closure error **(%)**
$\mathbf{F_{\mathit{W}\text{-design}}}$	Design permeate water flux **(gfd)**
$\mathbf{F_{\mathit{W}}(T^\circ C)}$	Water flux at ambient temperature, T°C, **(gfd)**
$\mathbf{F_{\mathit{W}}(Tavg^\circ C)}$	Water flux at the average yearly water temperature, Tavg°C, **(gfd)**
LSI	Langelier saturation index
MBAA	Monobromoacetic acid **(μg/L)**
MCAA	Monochloroacetic acid **(μg/L)**
MFI	Modified fouling index
MPFI	Mini plugging factor index
$\mathbf{MTC_{\mathit{W}}}$	Water mass transfer coefficient **(gfd/psi)**
$\mathbf{MTC_{\mathit{W}}(Tavg^\circ C)}$	Water mass transfer coefficient at average temperature, Tavg°C, **(gfd/psi)**
NA	Not analyzed
NDP	Net driving pressure **(psi)**
NR	Not reported
$\mathbf{P_C}$	Pressure of the concentrate stream **(psi)**
$\mathbf{P_I}$	Pressure of the influent stream **(psi)**
$\mathbf{P_p}$	Design permeate pressure **(psi)**
$\mathbf{Q_F}$	Feed flow rate **(gpm)**
$\mathbf{Q_I}$	Influent flow rate **(gpm)**
$\mathbf{Q_p}$	Permeate flow rate **(gpm)**
$\mathbf{Q_R}$	Concentrate-recycle flow rate **(gpm)**
$\mathbf{Q_T}$	Total product flow (i.e., permeate flow plus by-passed feed flow) **(gpm)**
$\mathbf{Q_W}$	Concentrate-waste flow rate **(gpm)**

r	Recycle ratio
$\mathbf{r_b}$	Permeate:total product flow blend ratio (i.e., $\mathbf{Q_p/Q_T}$)
R	Recovery **(decimal fraction)**
$\mathbf{R_B}$	Rejection based on the bulk concentration **(%)**
$\mathbf{R_F}$	Rejection based on the feed concentration **(%)**
$\mathbf{Rej_{TDS}}$	Manufacturer report rejection of TDS **(decimal fraction)**
SDI	Silt density index
SDS	Simulated distribution system
SDS-CD	SDS chlorine demand **(mg/L)**
SDS-Cl Dose	SDS chlorine dose **(mg/L)**
SDS-CR	SDS free chlorine residual **(mg/L)**
SDS-HAA5	The sum of five haloacetic acids evaluated under SDS conditions **(μg/L)**
SDS-HAA6	The sum of six haloacetic acids evaluated under SDS conditions **(μg/L)**
SDS-THM4	The sum of four trihalomethanes evaluated under SDS conditions **(μg/L)**
SDS-TOX	Total organic halides evaluated under SDS conditions **(μg $\mathbf{Cl^-}$/L)**
SUVA	Specific ultraviolet absorbance **(L/(mg*m))**
T	Thickness of the mesh feed spacer used in the full-scale element **(ft)**
T°C	Ambient temperature **(°C)**
Tavg°C	Average yearly water temperature at the plant **(°C)**
TBAA	Tribromoacetic acid **(μg/L)**
TCAA	Trichloroacetic acid **(μg/L)**
TDS	Total dissolved solids **(mg/L)**
$\mathbf{TDS_F}$	Total dissolved solids in the feed stream **(mg/L)**
$\mathbf{TDS_I}$	Total dissolved solids in the influent stream **(mg/L)**
$\mathbf{TDS_p}$	Total dissolved solids in the permeate stream **(mg/L)**
$\mathbf{TDS_W}$	Total dissolved solids in the concentrate-waste stream **(mg/L)**
TOC	Total organic carbon **(mg/L)**
$\mathbf{UV_{254}}$	Ultra-violet absorbance at 254 nm $\mathbf{(cm^{-1})}$
$\mathbf{v_c}$	Cross-flow velocity **(fps)**
w	Total width of all membrane envelopes in the SEBST element **(ft)**
$\Delta\pi$	Osmotic pressure gradient **(psi)**
$\Delta \mathbf{P_{loss}}$	Estimated system pressure losses **(psi)**

SEBST Design Calculations

Temperature Normalized MTC_W (Example cell: H6)

$$\mathbf{MTC_W(Tavg°C) = MTC_W(T°C) \times 1.03^{(Tavg°C - T°C)}} \qquad \textbf{(8a.1)}$$

Permeate Flow Rate (Example cell: H11)

$$\mathbf{Q_p = F_{W\text{-}design} \times A / 1440 \text{ (min per day)}} \qquad \textbf{(8a.2)}$$

Feed Flow Rate (Example cell: H12)

$$\mathbf{Q_F = Q_p / R} \qquad \textbf{(8a.3)}$$

Concentrate-Waste Flow Rate (Example cell: H13)

$$\mathbf{Q_W = Q_F - Q_p} \qquad \textbf{(8a.4)}$$

Concentrate-Recycle Flow Rate (Example cell: H17)

$$\mathbf{Q_R = Q_I - Q_F} \qquad \textbf{(8a.5)}$$

Recycle Ratio (Example cell: H18)

$$\mathbf{r = Q_R/Q_F} \qquad \textbf{(8a.6)}$$

Estimate of Concentrate-Waste, Permeate and Influent TDS Concentrations

Estimate of Concentrate-Waste TDS Concentration (Example cell: H27)

$$\mathbf{TDS_W = TDS_F \times (1 + r - R + (R \times Rej_{TDS}))/(1 + r - R - (r \times R \times Rej_{TDS}))} \qquad \textbf{(8a.7)}$$

Estimate of Permeate TDS Concentration (Example cell: H28)

$$\mathbf{TDS_p = (Q_F \times TDS_F - Q_W \times TDS_W)/Q_p} \qquad \textbf{(8a.8)}$$

Estimate of Influent TDS Concentration (Example cell: H29)

$$\mathbf{TDS_I = (Q_F \times TDS_F + r \times Q_F \times TDS_W)/Q_I} \qquad \textbf{(8a.9)}$$

Estimate of Osmotic and Influent Pressures

Osmotic Pressure For Design Calculations (Example cell: H30)

$$\Delta\pi = \mathbf{0.01 \times (((TDS_I + TDS_W)/2) - TDS_p)} \qquad \textbf{(8a.10)}$$

Design Influent Pressure (Example cell: H35)

$$\mathbf{P_I = F_W(Tavg°C)/MTC_W + \Delta P_{loss} + P_p} + \Delta\pi \qquad \textbf{(8a.11)}$$

Membrane Operating Parameters and Productivity

Feed Flow Rate (Example cells: AB7:AB50)

$$\mathbf{Q_F = Q_p + Q_W} \qquad \textbf{(8a.12)}$$

Influent Flow Rate (Example cells: AC7:AC50)

$$\mathbf{Q_I = Q_F + Q_R} \qquad \textbf{(8a.13)}$$

Cross-Flow Velocity (Example cells: AD7:AD50)

$$\mathbf{v_c = (Q_I - 0.5 \times Q_p)/(w \times T)) \times 2.228 \times 10^{-3} \text{ (cfs per gpm)}} \qquad \textbf{(8a.14)}$$

System Recovery (Example cells: AE7:AE50)

$$\mathbf{R = Q_p / Q_F} \qquad \textbf{(8a.15)}$$

Recycle Ratio (Example cells: AF7:AF50)

$$\mathbf{r = Q_R / Q_F} \qquad \textbf{(8a.16)}$$

Water Flux at Ambient Temperature (Example cells: AG7:AG50)

$$\mathbf{F_W(T°C) = (Q_p / A) \times 1440\ (min\ per\ day)} \qquad \textbf{(8a.17)}$$

Water Flux at Average Water Temperature (Example cells: AH7:AH50)

$$\mathbf{F_W(Tavg°C) = F_W(T°C) \times 1.03^{(Tavg°C - T°C)}} \qquad \textbf{(8a.18)}$$

Estimate of Osmotic Pressure Gradient (Example cells: AI7:AI50)

$$\Delta\pi = \mathbf{0.01 \times (TDS_B - TDS_p)} \qquad \textbf{(8a.19)}$$

Net Driving Pressure (Example cells: AJ7:AJ50)

$$\mathbf{NDP = ((P_I + P_C)/2) - P_p - \Delta\pi} \qquad \textbf{(8a.20)}$$

Water Mass Transfer Coefficient at Average Temperature (Example cells: AK7 - AK50)

$$\mathbf{MTC_W(Tavg°C) = F_W(Tavg°C) / NDP} \qquad \textbf{(8a.21)}$$

Water Quality Analysis

SDS-Chlorine Demand (Example cells: BP28:BQ28, CA28:CB28, CL28:CM28, CW28:CX28, DH28:DI28, DS28:DT28)

$$\mathbf{(SDS\text{-}CD) = (SDS\text{-}Cl\ Dose) - (SDS\text{-}CR)} \qquad \textbf{(8a.22)}$$

SDS-HAA5 (Example cells: BP47:BQ47, CA47:CB47, CL47:CM47, CW47:CX47, DH47:DI47, DS47:DT47)

$$\mathbf{SDS\text{-}HAA5 = MCAA + DCAA + TCAA + MBAA + DBAA} \qquad \textbf{(8a.23)}$$

SDS-HAA6 (Example cells: BP48:BQ48, CA48:CB48, CL48:CM48, CW48:CX48, DH48:DI48, DS48:DT48)

$$\mathbf{SDS\text{-}HAA6 = MCAA + DCAA + TCAA + MBAA + DBAA + BCAA} \qquad \textbf{(8a.24)}$$

SDS-THM4 (Example cells: BP37:BQ37, CA37:CB37, CL37:CM37, CW37:CX37, DH37:DI37, DS37:DT37)

$$\mathbf{SDS\text{-}THM4 = CHCl3 + BDCM + DBCM + CHBr3} \qquad \textbf{(8a.25)}$$

Calculated Concentrate Concentration (Example cells: AR7:AR50, AZ7:AZ50, BH7:BH50, BS16:BS48, CD16:CD48, CO16:CO48, CZ16:CZ48, DK16:DK48, DV16:DV48)

$$\mathbf{C_{C(calc)} = (C_F - R \times C_p) / (1\text{-}R)} \qquad \textbf{(8a.26)}$$

Mass Balance Closure Error (Example cells: AS7:AS50, BA7:BA50, BI7:BI50, BT16:BT23, CE16:CE23, CP16:CP23, DA16:DA23, DL16:DL23, DW16:DW23)

$$\mathbf{Error_{MB} = ((C_C - C_{C(calc)}) / C_C) \times 100\%} \qquad \textbf{(8a.27)}$$

Feed Rejection (Example cells: AT7:AT50, BB7:BB50, BJ7:BJ50, BU16:BU48, CF16:CF48, CQ16:CQ48, DB16:DB48, DM16:DM48, DX16:DX48)

$$\mathbf{R_F = ((C_F - C_p)/C_F) \times 100\%} \qquad \textbf{(8a.28)}$$

Bulk Concentration (Example cells:AU7:AU50, BC7:BC50, BK7:BK50, BV16:BV48, CG16:CG48, CR16:CR48, DC16:DC48, DN16:DN48, DY16:DY48)

$$\mathbf{C_B = (C_F \times Q_F + C_C \times (2 \times Q_I - Q_F))/2 \times Q_I} \qquad \textbf{(8a.29)}$$

Bulk Rejection (Example cells:AV7:AV50, BD7:BD50, BL7:BL50, BW16:BW48, CH16:CH48, CS16:CS48, DD16:DD48, DO16:DO48, DZ16:DZ48)

$$\mathbf{R_B = ((C_B - C_p)/C_B) \times 100\%} \qquad \textbf{(8a.30)}$$

Blend Ratio (Example cells: BO55:BT55, BZ55:CE55, CK55:CP55, CV55:DA55, DG55:DL55, DR55:DW55)

$$\mathbf{r_b = Q_p/Q_T = (C_F - C_{TG})/(C_F - C_p)} \qquad \textbf{(8a.31)}$$

C_{TG}(THM4, Stage 1) = 72 μg/L; C_{TG}(HAA5, Stage 1) = 54 μg/L;
C_{TG}(THM4, Stage 2) = 36 μg/L; C_{TG}(HAA5, Stage 2) = 27 μg/L

Blended Water Quality (Example cells: BO56:BT65, BZ56:CE65, CK56:CP65, CV56:DA65, DG56:DL65, DR56:DW65)

$$\mathbf{C_b = r_b \times (C_p - C_F) + C_F} \qquad \textbf{(8a.32)}$$

SUVA (Example cells: BP24:BR24, CA24:CC24, CL24:CN24, CW24:CY24, DH24:DJ24, DS24:DU24)

$$\mathbf{SUVA = (UV_{245}/TOC) \times 100(cm/m)} \qquad \textbf{(8a.33)}$$

9.0 Spreadsheet For Membrane Pilot-Scale Studies

The pilot-scale membrane spreadsheet (*mempilot.xls)* is designed to contain the data from one yearlong pilot membrane study. This spreadsheet consists of six (6) field-sets with thirteen (13) fields in each field-set. Each field-set is located on a separate worksheet, and Table 9-1 summarizes the designation, sheet title and cell range for each field-set.

Field-Set Title (Designation)	Sheet Title	Field-Set Cell Range
Example Pilot-Scale Membrane Data (E-)	Sheet0. Example Data	A1:HL76
Pilot-Scale Membrane Results: Weeks 1-10 (1-)	Sheet1. Weeks 1-10	A1:HL220
Pilot-Scale Membrane Results: Weeks 11-20 (2-)	Sheet2. Weeks 11-20	A1:HL220
Pilot-Scale Membrane Results: Weeks 21-30 (3-)	Sheet3. Weeks 21-30	A1:HL220
Pilot-Scale Membrane Results: Weeks 31-40 (4-)	Sheet4. Weeks 31-40	A1:HL220
Pilot-Scale Membrane Results: Weeks 41-50 (5-)	Sheet5. Weeks 41-50	A1:HL220

Table 9-1 Summary Of Pilot-Scale Membrane Field-Sets And Corresponding Sheet Titles

The Example Field-Set demonstrates the use of the pilot membrane spreadsheet. Example data are presented in each field to clarify the use of these spreadsheets and to verify that the equations are functioning properly. The entire Example Field-Set is Locked and Protected to prevent data entry on this sheet. Each of the Field-Sets 1 through 5, are used to enter the results from ten weeks of pilot-scale membrane operation. For example, Field-Set 1 is used to report the results from weeks 1 through 10, Field-Set 2 is used to report the results from weeks 11 through 20, Field-Set 3 is used to report the results from weeks 21 through 30 etc.

The thirteen fields in each field-set are identified by the field-set designation (i.e., E, 1, 2, 3, 4, or 5) followed by a field designation (i.e., 1 through 13). For example, Field 1-6 is the sixth field in Field-Set 1, and Field 5-6 is the sixth field in Field-Set 5. Furthermore, fields with the same *field designation* are identical (e.g., Field 1-6 is the same as Field 5-6 except that Field 1-6 is used to report results from the first ten weeks of pilot-scale membrane operation, and Field 5-6 is used to report results from the last ten weeks of pilot-scale membrane operation). The field titles, designations and cell ranges are summarized in Table 9-2, and the individual fields are described in Sections 9.1 through 9.13.

9.1 Field 1: PWS And Treatment Plant Data *(A3:B30)*

Exhibit 9-1 presents an example of Field 1 which is used to enter the Public Water System (PWS) and treatment plant data, including the PWSID#, plant ICR #, and addresses and phone numbers of the official and technical ICR contacts. Some of the information in Field 1 is optional (i.e., the WIDB number and e-mail addresses).

Field Title	Designation	Field Cell Range
PWS and Treatment Plant Data	1	A3:B30
Manufacturer Reported Membrane Characteristics	2	D3:E45
2-Stage Membrane Pilot System Design Parameters	3	G3:H68
Foulants and Fouling Indices	4	J3:K29
Pretreatment Used Prior to Membranes	5	M3:O24
Membrane Performance Data During Operation With The Test Water	6	Q3:CS220
System And Stage Water Quality For Week 2 (12, 22, 32, 42)[1]	7	CU3:DM76
System And Stage Water Quality For Week 4 (14, 24, 34, 44)	8	DO3:EG76
System And Stage Water Quality For Week 6 (16, 26, 36, 46)	9	EI3:FA76
System And Stage Water Quality For Week 8 (18, 28, 38, 48)	10	FC3:FU76
System And Stage Water Quality For Week 10 (20, 30, 40, 50)	11	FW3:GO76
Duplicate Analysis Of System And Stage Water Quality For Week 10 (20, 30, 40, 50)	12	GQ3:HI76
Membrane Cost Parameters	13	HK3:HL20

1: The numbers in parentheses are the week designations for the second, third, fourth and fifth Field-Sets. For example, Field 10 is used to report results from week 8 in Field-Set 1, week 18 in Field-Set 2, week 28 in Field-Set 3, week 38 in Field-Set 4 and week 48 in Field-Set 5.

Table 9-2 Summary Of Pilot-Scale Membrane Data Fields

9.2 Field 2: Manufacturer Reported Membrane Characteristics *(D3:E45)*

Exhibit 9-2 presents an example of Field 2 which is used to enter the manufacturer reported characteristics of the membrane used in the pilot-scale membrane study. The first block of cells in Field 2, ***General Information (D4:E12)*** is used to enter information including the membrane manufacturer, trade name, membrane element model number, molecular weight cutoff, etc. The second block, ***Design Parameters (D14:E26)***, is used to enter values for the parameters that will be used in the design of the pilot-scale membrane study, and all of the information in this block **must** be entered including:

- The size of the elements used during the study, such as a 2.5" x 40" element or a 4" x 40" element. (The minimum element size that can be used is a 2.5" x 40".)

- The active membrane area of a single element used in the study (A) in **ft^2**.
- The design flux (F_W) in **gfd**.
- The net driving pressure (NDP) at this design flux in **psi**.
- The water mass transfer coefficient, or water flux per unit of net driving pressure (MTC_W) in **gfd/psi**. (If the MTC_W is not explicitly reported by the manufacturer, it can be calculated by dividing the design flux by the net driving pressure at this design flux.)
- The temperature (T°C) at which the design flux or MTC_W was measured in **°C**.
- The maximum ($Q_{I, max}$) and minimum ($Q_{I, min}$) allowable flow rates to the elements used in the study in **gpm**.
- The total width of all membrane envelopes in one of the elements used in the study (w) in **ft** (i.e., this is the *width* of the feed flow channel in a single membrane element).
- The thickness of the feed spacer in one of the elements used in the study (T) in **ft** (i.e., this is the *thickness* of the feed flow channel in a single membrane element).
- The active membrane area of an equivalent 8" x 40" membrane element in **ft^2**.
- The purchase price of an equivalent 8" x 40" membrane element in **$**.

The third block in this field ***(D28:E43)*** is used to report additional information such as the required feed flow to permeate flow ratio, the maximum element recovery, and other information that could be used during the design of the pilot-scale membrane study.

9.3 Field 3: 2-Stage Membrane Pilot System Design Parameters *(G3:H68)*

Exhibit 9-3 presents an example of Field 3 which uses information entered in Field 2 as well as additional input design parameters to calculate the operating parameters for a 2-stage pilot-scale membrane system.

In the first block of this field, ***Calculate Temperature Normalized MTC_W (G4:H6)***, the user must enter the average yearly water temperature of the feed water at the plant in **°C**, and the spreadsheet will calculated the MTC_W normalized to this average yearly water temperature. In the second block, ***Calculate System Permeate, Feed and Waste Flow Rates (G8:H20)***, the user must enter the design recovery as a decimal fraction (i.e., this should be *at least* 0.75 according to the requirements in the *ICR Manual for Bench- and Pilot-Scale Treatment Studies*), the number of elements per pressure vessel (N_e) and the number of pressure vessels in each stage ($N_{v\text{-}s(i)}$). The spreadsheet assumes that all pressure vessels contain the same number of elements and that all membrane elements are of the same size and type. (If this is not the case, manual calculations will be necessary to develop the system design.) The spreadsheet uses this information to calculate the following flow rates in gallons per minute:

- The permeate flow rate per element ($Q_{p\text{-}e}$) in **gpm**.
- The permeate flow rate per pressure vessel ($Q_{p\text{-}v}$) in **gpm**
- The permeate flow rate from each stage ($Q_{p\text{-}s(i)}$) in **gpm**.
- The permeate flow rate from the system ($Q_{p\text{-}sys}$) in **gpm**.
- The feed flow rate to the system ($Q_{F\text{-}sys}$) in **gpm**.
- The concentrate-waste flow rate from the system ($Q_{W\text{-}sys}$) in **gpm**.

The next block, ***Calculate the Feed Flow Rate at the End of Each Stage (G22:H24)***, calculates the flow entering the last element in a stage as the difference between the feed flow entering that stage and the permeate flow produced by the upstream elements in that stage. The following two blocks, ***Calculate the Minimum/Maximum Recycle Flow Rate for Each Stage (G26:H30*** and ***G32:H34)***, calculate the minimum recycle flow rate ($(Q_{R\text{-}s(i)})_{min}$) and the maximum recycle flow rate ($(Q_{R\text{-}s(i)})_{max}$) that can be applied to each stage based on the manufacturer specifications and the system configuration. The following block, ***Select the Design System Recycle Flow Rate (G36:H43)***, specifies the minimum recycle flow rate ($(Q_{R\text{-}sys})_{min}$) and the maximum recycle flow rate ($(Q_{R\text{-}sys})_{max}$) to be applied to the *system*. The minimum required recycle flow rate for the system is specified as the largest "minimum recycle flow rate" for any stage in the system. The maximum allowable recycle flow rate for the system is specified as the smallest "maximum recycle flow rate" for any stage in the system. The user must enter a design system recycle flow rate ($Q_{R\text{-}sys}$) between the minimum and maximum *system* recycle flow rates. Once the design system recycle flow rate is entered by the user, the spreadsheet calculates the influent flow rate ($Q_{I\text{-}sys}$) to the system (i.e., the sum of the feed and concentrate-recycle flow rates) and the recycle ratio (r). Note that these calculations assume concentrate recycle around the system; however, it is permissible to recycle around individual stages. If individual stage recycle is employed, the stage recycle flow rate must be within the minimum and maximum values for that stage.

The next block, ***Summary of Stage and System Flow Rates (G45:H55)***, lists all of the flow rates in the systems that need to be measured directly or calculated. This table can be used to size the flow meters and pumps used in the pilot system.

The final block in this field, ***Calculate the Required System Influent Pressure (G57:H68)***, requires the user to enter estimates of the following pressure losses:

- The osmotic pressure gradient for each stage ($\Delta\pi_i$) in **psi**. (Estimates of the osmotic pressure gradient for a 2-stage system can be found in Table 6-5 of Part 3 of the *ICR Manual for Bench- and Pilot-Scale Treatment Studies*.)
- An estimate of the pressure losses associated with stage hardware (ΔP_s) in **psi**.
- An estimate of the pressure losses through a single membrane element (ΔP_e) in **psi**.
- The design permeate pressure for the system (P_p) in **psi**.

These estimated pressure losses are used to calculate the mechanical pressure losses in each stage. The pressure required for permeation is calculated by dividing the design flux by the water mass transfer coefficient. A flow-weighted pressure loss term is calculated for the system and the required influent pressure is calculated by summing the flow-weighted pressure loss, the pressure required for permeation and the design permeate pressure.

The flow rates and pressures calculated in this field are intended to provide design criteria for the pilot-scale membrane system and a starting point for the operating parameters used in the study. The waste flow rate and influent pressure may need to be adjusted during the course of the run to obtain the desired recovery and permeate flux.

9.4 Field 4: Foulants And Fouling Indices *(J3:K29)*

Exhibit 9-4 shows an example of Field 4 which is used to report the concentrations of various foulants and the values of fouling indices for the feed water prior to pretreatment. Numerous water quality parameters that could constitute a fouling problem are included here, however only those parameters relevant to the water being tested need to be evaluated. Foulants and indices not listed in this field, but which are evaluated as part of the study, should be reported in the blank rows. The information in this field should be used to select appropriate pretreatment to membrane separations in order to minimize fouling.

9.5 Field 5: Pretreatment Used Prior To Membranes *(M3:O24)*

Field 5 is used to report all pretreatment processes used prior to the pilot membrane system, and Exhibit 9-5 presents an example of Field 5. All full-scale and pilot-scale pretreatment processes should be listed in this field. The process name should be entered, along with a brief description of the process (e.g., chemical dose, cartridge filter exclusion size, etc.) and the scale of the process (i.e., full-scale or pilot-scale). Detailed design information is not required in this spreadsheet since this design data will be included in the hard-copy *Treatment Study Summary Report* as described in Section 10.0 of this document. The purpose of Field 5 is to associate the pretreatment processes used during the pilot-scale membrane study with the data entered in the spreadsheet.

9.6 Field 6: Membrane Performance Data During Operation With The Test Water *(Q3:CS220)*

Field 6 is used to report the parameters monitored during operation with the pretreated test water, and an example of Field 6 is shown in Exhibit 9-6.

Note: Only one-fifth of the operational data from the total run time (i.e., data from approximately 1320 hours of operation) will be reported in Field 6 of each field-set.

Field 6 is divided into three blocks: ***System Operating Parameters (Q3:CS220)***, ***Stage 1 Operating Parameters (AW3:BT220)*** and ***Stage 2 Operating Parameters (BV3:CS220)***. In the first block of this field, the date, time and cumulative operation time must be reported for each monitoring event. A monitoring event includes measurements of both *system* and *stage* operating parameters. The operation time is reported in decimal hours and is defined with respect to the starting date and time of operation of the pilot membrane system with the pretreated test water. Any period of time during which system operation is interrupted (e.g., during a cleaning event) must not be included in the cumulative operation time. Times at which the system is cleaned should be indicated with an "**X**" in column ***AA*** of this block.

The *system* operating parameters that are reported in this block include, the influent temperature and pressure; the system concentrate and permeate pressures; and the permeate, concentrate-recycle and concentrate-waste flow rates for the system. The spreadsheet uses these entered values to calculate operating parameters such as the system feed flow rate, recovery, flux, temperature normalized flux, net driving pressure and water mass transfer coefficient. **It is important to enter all measured parameters in the specified units: temperature in °C, pressure in psi and flow rate in gpm.**

The temperature normalized flux is calculated using a generic temperature correction equation (see Equation 9a.29 in Appendix 9a). If a membrane specific temperature correction equation is provided by the manufacturer, it should be used instead of Equation 9a.29. To use a different temperature correction equation, overwrite the existing equation in cells

AG8:AG220, ***BG8:BG220*** and ***CF8:CF220***, making sure that the revised equation references the proper cells. To overwrite an equation in the spreadsheet, the sheet must be Unprotected, and the cells containing the equation must be unLocked as described in Section 3.3.

The first block of Field 6 is also used to report the feed pH and TDS concentration before and after acid addition, and the system permeate and concentrate TDS concentrations. The TDS and pH must be monitored every time the system flows and pressures are monitored. For TDS, the spreadsheet will calculate the feed rejection (R_F), the calculated concentrate concentration ($C_{C(calc)}$), the bulk concentration (C_B), the bulk rejection (R_B), and the mass balance closure error ($Error_{MB}$).

The second and third blocks of Field 6 are used to report the operating parameters monitored for *stages 1* and *2*, respectively. These operating parameters include the influent, concentrate and permeate pressures for each stage, and the permeate and concentrate flow rates from each stage. Similar to the first block, the second and third blocks calculate operating parameters such as the feed and influent flow rates to each stage, the stage recovery, the cross-flow velocity through each stage, the flux, the temperature normalized flux, the net driving pressure and the water mass transfer coefficient. The temperature normalized flux is calculated using a generic temperature correction equation (see Equation 9a.29 in Appendix 9a). If a membrane specific temperature correction equation is provided by the manufacturer, it should be used instead of Equation 9a.29. To use a different temperature correction equation, overwrite the existing equation in cells ***AG8:AG220***, ***BG8:BG220*** and ***CF8:CF220***, making sure that the revised equation references the proper cells. To overwrite an equation in the spreadsheet, the sheet must be Unprotected, and the cells containing the equation must be unLocked as described in Section 3.3.

The second and third block are also used to report the influent and concentrate pH values for each stage; and the permeate, influent and concentrate TDS concentrations for each stage. For TDS, the spreadsheet will calculate the feed rejection (R_F), the calculated concentrate concentration ($C_{C(calc)}$), the bulk concentration (C_B), the bulk rejection (R_B), and the mass balance closure error ($Error_{MB}$).

9.7 Fields 7 Through 12: System And Stage Water Quality For Week ___ *(CU3:DM76; DO3:EG76; EI3:FA76; FC3:FU76; FW3:GO76; GQ3:HI76)*

Fields 7 through 12 are used to report the permeate, feed and concentrate water quality for every other week of pilot membrane operation, and an example of Field 7 is shown in Exhibit 9-7. Fields 7 through 12 appear in all five of the pilot membrane field-sets, and are used to report data from different weeks of pilot operation. Table 9-3 summarizes the field-set/field designations (i.e., Field 1-7 through Field 5-12) that are used to report the results from each set of bi-weekly water quality analyses.

Field Designation	**Week of Pilot-Scale Membrane Operation**				
	Field-Set 1	***Field-Set 2***	***Field-Set 3***	***Field-Set 4***	***Field-Set 5***

7	Week 2	Week 12	Week 22	Week 32	Week 42
8	Week 4	Week 14	Week 24	Week 34	Week 44
9	Week 6	Week 16	Week 26	Week 36	Week 46
10	Week 8	Week 18	Week 28	Week 38	Week 48
11	Week 10	Week 20	Week 30	Week 40	Week 50
12	Week 10, dup[1]	Week 20, dup	Week 30, dup	Week 40, dup	Week 50, dup

1: dup indicates results from a duplicate analyses of the water quality parameters for the designated week are reported in the specified field.

Table 9-3 Field Designations For The Bi-Weekly Water Quality Data Reported In Each Pilot-Scale Membrane Field-Set

The date, time and operation time at which each sample is collected must be entered in these fields. The following water quality parameters are to be analyzed and reported for the system permeate and system feed samples: pH, temperature, alkalinity, TDS, total hardness, calcium hardness, turbidity, ammonia, TOC, UV_{254}, bromide, SDS-chlorine demand, SDS-TOX, SDS-THM4 and SDS-HAA6[1].

The following water quality parameters are to be analyzed and reported for the system concentrate, the permeate from each stage and the influent to each stage: pH, temperature, alkalinity, TDS, total hardness, calcium hardness, turbidity, TOC and UV_{254}. For both system and stage measurements, the spreadsheet will automatically calculate the mass balance closure error for these water quality parameters with the exception of pH and temperature.

The spreadsheet also calculates the concentrate concentration, the feed rejection, the bulk concentration and the bulk rejection, as well as the SDS-chlorine demand, SDS-THM4, SDS-HAA5 and SDS-HAA6.

In order to calculate the mass balance closure error, bulk concentration and bulk rejection, specific operating parameters must be entered in Field 7. The following system operating parameters must be entered in cells ***CX5:CX7*** of Field 7: the system recovery, system feed flow rate and system influent flow rate. The following stage 1 and stage 2 operating parameters must be entered in cells ***DI5:DI7*** and ***DI27:DI29*** of Field 7: the stage recovery, stage permeate flow rate and stage influent flow rate. These operating parameters must reflect the conditions of the system or stage during the time at which the permeate, feed, influent and concentrate samples are collected. The recovery must be expressed as a decimal fraction and the flow rates must be expressed in gpm.

The block entitled, ***Blending Calculation for D-DBP MCLs (CU52:DA76)***, in Field 7

[1]Only six HAA species are required, but the additional three HAA species (TBAA, CDBAA and DCBAA) should be reported if measured.

calculates the permeate flow to total product flow ratio (i.e., blend ratio) that can be used to meet the Stage 1 and proposed Stage 2 D-DBP MCLs with a 10% factor of safety. The spreadsheet uses the system permeate and feed concentrations entered in block ***(CU9:DD50)*** of Field 7 to calculate the permeate to total product flow ratio (Q_p/Q_T) required to achieve the D-DBP MCLs with a 10% factor of safety. For Stage 1, 90% of the D-DBP MCLs are 72 μg/L for THM4 and 54 μg/L for HAA5. For Stage 2, 90% of the D-DBP MCLs are 36 μg/L for THM4 and 27 μg/L for HAA5. The blend ratio is used to calculate the water quality of the feed/permeate blend. Blended water qualities are indicated by the subscript "b" and are calculated for SDS-THM4, SDS-HAA5, SDS-TOX, SDS-CD, TOC, UV_{254}, bromide, alkalinity, total hardness and calcium hardness.

In some cases, the blending calculations are meaningless. If the permeate concentration does not meet 90% of the DBP MCL prior to blending, then the blend ratio will be greater than 100% indicating that blending is not feasible. If the feed concentration meets 90% of the DBP MCL prior to blending then nanofiltration is not required to meet the MCL and the blend ratio will be negative. In both of these cases, the spreadsheet will report "NA" for the blended water quality parameters since the calculated values have no physical significance.

When the blending calculations are relevant, the user must compare the blend ratios calculated for THM4 and HAA5 since the higher blend ratio is the minimum ratio that will meet both MCLs with a 10% factor of safety. For example, in Exhibit 9-7 the THM4 MCL controls the blend ratio for both Stage 1 and Stage 2.

9.8 Field 13: Membrane Cost Parameters *(HK3:HL20)*

Field 13 is used to report the utility-specific cost parameters that are used to generate cost estimates for the use of membrane technology, and an example of Field 13 is shown in Exhibit 9-8. Example cost parameters are listed in Exhibit 9-8, but it is important to report cost parameters specific to the utility and not default or example values.

	A	B
3	**Field E-1: PWS And Treatment Plant Data**	
4		
5	PWS Name	Anytown Public Works
6	Public Water System Identification Number	OH1234567
7	Water Industry Data Base Number (*optional*)	######
8		
9	Official ICR Contact Person	Mr. Any Body
10	Mailing Address	#### Street
11		City, State Zip code
12	Phone Number	(###) ###-####
13	FAX Number	(###) ###-####
14	E-Mail Address (*optional*)	last.first@wtp.com
15		
16	Technical ICR Contact Person	Ms. Some One
17	Mailing Address	#### Street
18		City, State Zip code
19	Phone Number	(###) ###-####
20	FAX Number	(###) ###-####
21	E-Mail Address (*optional*)	last.first@wtp.com
22		
23	Plant Name	East WTP
24	Treatment Plant Category	CONV
25	Process Train Name	Conventional train
26	ICR Treatment Plant Identification Number	###
27	PWSID Number of Plant (*if assigned*)	Not assigned
28	Historical Minimum Water Temperature (^{o}C)	4.0
29	Historical Average Water Temperature (^{o}C)	18.0
30	State Approved Plant Capacity (MGD)	100.0
31		
32	**Exhibit 9-1 Example Of Field 1 For The Membrane Pilot Data Sheet**	

	D	E
3	**Field E-2: Manufacturer Reported Membrane Characteristics**[1]	
4	***General Information***	
5	Membrane manufacturer	Company Name
6	Membrane trade name	NFPA-200
7	Membrane element model number	NFPA-200 4040
8	Molecular weight cutoff (Daltons)	200
9	Membrane material (e.g., PVD, polyamide, etc.)	polyamide
10	Membrane construction (e.g., thin-film composite)	thin-film composite
11	Membrane hydrophobicity	hydrophilic
12	Membrane charge (e.g., negative, highly negative, neutral, etc.)	highly negatively charged
13		
14	***Design Parameters***	
15	Element size (e.g., 2.5" x 40", 4" x 40", etc.)	4" x 40"
16	Active membrane area of membrane element used, A (ft^2)	70.0
17	Design flux, F_W (gfd)	15.0
18	Net driving pressure at the design flux, NDP (psi)	80.0
19	Water mass transfer coefficient, MTC_W (gfd/psi)	0.188
20	Temperature at which the MTC_W was determined, T^oC (^oC)	25.0
21	Maximum flow rate to the element, $Q_{I, max}$ (gpm)	16.0
22	Minimum flow rate to the element, $Q_{I, min}$ (gpm)	4.0
23	Total width of all membrane envelopes in the element, w (ft)	12.0
24	Feed spacer thickness, T (ft)	0.0025
25	Active membrane area of an equivalent 8" x 40" element (ft^2)	315.0
26	Purchase price for an equivalent 8" x 40 " element ($)	1000.00
27		
28	***Additional Information***	
29	Design cross-flow velocity (fps)	0.257
30	Required influent flow to permeate flow rate ratio, Q_I:Q_p	6:1
31	Maximum element recovery (%)	16
32	Variability of design flux (%)	15
33	Rejection of reference solute and conditions of test	90% rejection of a 2000 mg/L
34	(e.g., solute type and concentration)	$MgSO_4$ solution
35	Variability of rejection of reference solute (%)	1
36	Standard testing recovery (%)	15
37	Standard testing pH	7
38	Acceptable range of operating pressures	0 - 250
39	Acceptable range of operating pH values	3 - 9
40	Typical pressure drop across a single element (psi)	5
41	Maximum permissible SDI	5
42	Maximum permissible turbidity (ntu)	Not reported
43	Chlorine/oxidant tolerance (e.g., < 0.1 mg/L for extended use, etc.)	1.0 mg/L maximum
44	1: All of the information requested in this field may not be available, but values for all of the ***Design***	
45	***Parameters*** must be entered in cells E15:E26, since these parameters are used in calculations.	
46		
47	**Exhibit 9-2 Example Of Field 2 For The Membrane Pilot Data Sheet**	

	G	H
3	**Field E-3: 2-Stage Membrane Pilot System Design Parameters**	
4	***Calculate Temperature Normalized MTC $_W$***	
5	Average yearly temperature of feed water, Tavg°C (°C)	18.0
6	Temperature normalized MTC_W (gfd/psi)	0.152
7		
8	***Calculate System Permeate, Feed and Waste Flow Rates***	
9	Design system recovery, R (decimal)	0.75
10	Design average system flux, F_W (gfd)	15.0
11	Number of elements per pressure vessel, N_e	3
12	Number of parallel pressure vessels in stage 1, $N_{v\text{-}s(1)}$	2
13	Number of parallel pressure vessels in stage 2, $N_{v\text{-}s(2)}$	1
14	Permeate flow rate per element, $Q_{p\text{-}e}$ (gpm)	0.73
15	Permeate flow rate per pressure vessel, $Q_{p\text{-}v}$ (gpm)	2.19
16	Permeate flow rate from stage 1, $Q_{p\text{-}s(1)}$ (gpm)	4.38
17	Permeate flow rate from stage 2, $Q_{p\text{-}s(2)}$ (gpm)	2.19
18	Permeate flow rate from system, $Q_{p\text{-}sys}$ (gpm)	6.56
19	Feed flow rate to system, $Q_{F\text{-}sys}$ (gpm)	8.75
20	Concentrate-waste flow rate from system, $Q_{W\text{-}sys}$ (gpm)	2.19
21		
22	***Calculate the Feed Flow Rates at the End of Each Stage***	
23	Feed flow rate at the end of stage 1, $(Q_{F\text{-}s(1)})_{end}$ (gpm)	5.83
24	Feed flow rate at the end of stage 2, $(Q_{F\text{-}s(2)})_{end}$ (gpm)	2.92
25		
26	***Calculate the Minimum Recycle Flow Rates for Each Stage***[1]	
27	Minimum recycle flow rate for stage 1, $(Q_{R\text{-}s(1)})_{min}$ (gpm)	2.17
28	Minimum recycle flow rate for stage 2, $(Q_{R\text{-}s(2)})_{min}$ (gpm)	1.08
29	1: A negative minimum recycle flow rate indicates that recycle is not required to	
30	meet the manufacturer's minimum flow requirement.	
31		
32	***Calculate the Maximum Recycle Flow Rates for Each Stage***	
33	Maximum recycle flow rate for stage 1, $(Q_{R\text{-}s(1)})_{max}$ (gpm)	23.25
34	Maximum recycle flow rate for stage 2, $(Q_{R\text{-}s(2)})_{max}$ (gpm)	11.63
35		
36	***Select the Design System Recycle Flow Rate***[2]	
37	Minimum system recycle flow rate, $(Q_{R\text{-}sys})_{min}$ (gpm)	2.17
38	Maximum system recycle flow rate, $(Q_{R\text{-}sys})_{max}$ (gpm)	11.63
39	Design system recycle flow rate, $Q_{R\text{-}sys}$ (gpm)	6.00
40	System influent flow rate, $Q_{I\text{-}sys}$ (gpm)	14.75
41	Recycle ratio, r	0.69
42	2: The **design system recycle flow rate** must fall between the **minimum** and	
43	**maximum** system recycle flow rates.	
44		
45	***Summary of the Stage and System Flow Rates***	
46	Influent flow rate to stage 1, $Q_{I\text{-}s(1)}$ (gpm)	14.75
47	Permeate flow rate from stage 1, $Q_{p\text{-}s(1)}$ (gpm)	4.38
48	Concentrate flow rate from stage 1, $Q_{C\text{-}s(1)}$ (gpm)	10.38
49	Influent flow rate to stage 2, $Q_{I\text{-}s(2)}$ (gpm)	10.38
50	Permeate flow rate from stage 2, $Q_{p\text{-}s(2)}$ (gpm)	2.19
51	Concentrate flow rate from stage 2, $Q_{C\text{-}s(2)}$ (gpm)	8.19
52	System concentrate recycle flow rate, $Q_{R\text{-}sys}$ (gpm)	6.00
53	System concentrate waste flow rate, $Q_{W\text{-}sys}$ (gpm)	2.19
54	System permeate flow rate, $Q_{p\text{-}sys}$ (gpm)	6.56
55	System feed flow rate, $Q_{F\text{-}sys}$ (gpm)	8.75
56		
57	***Calculate the Required System Influent Pressure***	
58	Osmotic pressure for stage 1[3], $\Delta\pi_1$ (psi)	2.0
59	Osmotic pressure for stage 2[3], $\Delta\pi_2$ (psi)	4.0
60	Pressure losses due to stage hardware, ΔP_s (psi)	4.0
61	Pressure losses in a single element, ΔP_e (psi)	2.0
62	Design permeate pressure, P_p (psi)	0.0
63	Mechanical pressure losses per stage, L_s (psi)	10.0
64	Net driving pressure required for permeation, NDP (psi)	98.4
65	Flow weighted system pressure losses, L_{sys} (psi)	14.3
66	Required influent pressure to the system, P_I (psi)	112.7
67	3: The osmotic pressure can be estimated from Table 6-5 in Part 3 of the	
68	"ICR Manual for Bench- and Pilot-Scale Treatment Studies."	
69		
70	**Exhibit 9-3 Example Of Field 3 For The Membrane Pilot Data Sheet**	

	J	K
3	**Field E-4: Foulants And Fouling Indices**[1]	
4	***Parameters Evaluated Prior to Pretreatment***	
5	Alkalinity (mg/L as $CaCO_3$)	40
6	Calcium Hardness (mg/L as $CaCO_3$)	79
7	LSI	1.4
8	Dissolved iron (mg/L)	15
9	Total iron (mg/L)	17
10	Dissolved aluminum (mg/L)	
11	Total aluminum (mg/L)	
12	Fluoride (mg/L)	
13	Phosphate (mg/L)	
14	Sulfate (mg/L)	
15	Calcium (mg/L)	
16	Barium (mg/L)	
17	Strontium (mg/L)	
18	Reactive silica (mg/L as SiO_2)	
19	Turbidity (ntu)	5
20	SDI	4
21	MFI	
22	MPFI	
23		
24		
25		
26		
27		
28	1: Only those foulants and fouling indices relevant to the water being tested need to	
29	be evaluated. Additional foulants and indices can be listed in the blank rows.	
30		
31	**Exhibit 9-4 Example Of Field 4 For The Membrane Pilot Data Sheet**	

	M	N	O
3	**Field E-5: Pretreatment Used Prior To Membranes**[1]		
4			
5	**Process**	**Description**	**Scale**
6	Coagulation	50 $\pm$ 15 mg/L alum	Full-scale
7	Flocculation	2-stage	Full-scale
8	Sedimentation	tube settler	Full-scale
9	Dual media filtration	sand / anthracite	Full-scale
10	Cartridge filtration	2 μm exclusion size	Pilot-scale
11	Sulfuric acid addition	pH = 6.0	Pilot-scale
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22	1: Design information, similar to that shown in Tables 6c and 6d of the ICR rule, must be included in		
23	the hard-copy *Treatment Study Summary Report* (see Section 10.0). The purpose of this table		
24	is to list the pretreatment processes used in this particular pilot-scale run.		
25			
26	**Exhibit 9-5 Example Of Field 5 For The Membrane Pilot Data Sheet**		

	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
3	**Field E-6: Membrane Performance Data During Operation With The Test Water**																	
4	***System Operating Parameters***																	
5	Date	Time	Operation		**SYSTEM**		**SYSTEM**		**SYSTEM**		**SYSTEM**		**SYSTEM**		**SYSTEM**		**SYSTEM**	
6			time	Influent	P_I	P_C	P_P	Q_R	Q_p	Q_W	Cleaning Event	Q_F	Q_I	Recovery	Recycle	F_W (T^oC)	F_W ($Tavg^oC$)	$\Delta\pi$
7	MM/DD/YY	hh:mm	hh.hh	Temp. (^oC)	(psi)	(psi)	(psi)	(gpm)	(gpm)	(gpm)	Indicate with "**X**"	(gpm)	(gpm)	(decimal)	ratio	(gfd)	(gfd)	(psi)
8	4/1/96	8:00	0.00	18.0	113.0	93.0	1.0	5.90	6.80	2.15		8.95	14.85	0.76	0.66	15.54	15.54	2.6
9	4/2/96	8:00	24.00	18.1	114.0	92.0	1.0	6.00	6.75	2.15		8.90	14.90	0.76	0.67	15.43	15.38	2.7
10	4/3/96	8:00	48.00	18.0	115.0	93.0	1.0	6.00	6.80	2.20		9.00	15.00	0.76	0.67	15.54	15.54	2.7
11	4/4/96	8:00	72.00	18.2	115.0	93.0	1.0	5.90	7.00	2.20		9.20	15.10	0.76	0.64	16.00	15.91	2.8
12	4/5/96	8:00	96.00	18.2	116.0	91.0	1.0	6.10	6.95	2.20		9.15	15.25	0.76	0.67	15.89	15.79	2.9
13	4/6/96	8:00	120.00	18.3	116.0	92.0	1.0	6.10	6.85	2.25		9.10	15.20	0.75	0.67	15.66	15.52	2.6
14	4/7/96	8:00	144.00	18.3	116.0	92.0	1.0	6.00	6.75	2.25		9.00	15.00	0.75	0.67	15.43	15.29	2.6
15	4/8/96	8:00	168.00	18.3	116.0	93.0	1.0	6.00	6.70	2.20		8.90	14.90	0.75	0.67	15.31	15.18	2.7
16	4/9/96	8:00	192.00	18.4	117.0	93.0	1.0	6.05	6.65	2.25		8.90	14.95	0.75	0.68	15.20	15.02	2.7
17	4/10/96	8:00	216.00	18.3	117.0	93.0	1.0	6.10	6.60	2.15		8.75	14.85	0.75	0.70	15.09	14.95	2.5
18	4/11/96	8:00	240.00	18.3	117.0	92.0	1.0	5.95	6.65	2.15		8.80	14.75	0.76	0.68	15.20	15.07	2.7
19	4/12/96	8:00	264.00	18.2	117.0	93.0	1.0	6.00	6.55	2.20		8.75	14.75	0.75	0.69	14.97	14.88	2.4
20	4/13/96	8:00	288.00	18.1	117.0	93.0	1.0	6.00	6.60	2.20		8.80	14.80	0.75	0.68	15.09	15.04	2.6
21	4/14/96	8:00	312.00	18.0	117.0	92.0	1.0	5.90	6.70	2.20		8.90	14.80	0.75	0.66	15.31	15.31	2.6
22	4/15/96	8:00	336.00	18.1	118.0	93.0	1.0	5.90	6.75	2.20		8.95	14.85	0.75	0.66	15.43	15.38	2.7
23	4/16/96	8:00	360.00	18.0	118.0	93.0	1.0	5.95	6.75	2.25		9.00	14.95	0.75	0.66	15.43	15.43	2.7
24	4/17/96	8:00	384.00	18.2	118.0	91.0	1.0	6.05	6.65	2.15		8.80	14.85	0.76	0.69	15.20	15.11	2.8
25	4/18/96	8:00	408.00	18.2	118.0	92.0	1.0	6.00	6.55	2.25		8.80	14.80	0.74	0.68	14.97	14.88	2.7
26	4/19/96	8:00	432.00	18.3	119.0	92.0	1.0	6.00	6.55	2.25		8.80	14.80	0.74	0.68	14.97	14.84	2.8
27	4/20/96	8:00	456.00	18.3	119.0	92.0	1.0	6.10	6.55	2.20		8.75	14.85	0.75	0.70	14.97	14.84	2.8
28	4/21/96	8:00	480.00	18.3	119.0	93.0	1.0	6.00	6.60	2.20		8.80	14.80	0.75	0.68	15.09	14.95	2.6
29	4/22/96	8:00	504.00	18.4	119.0	93.0	1.0	6.15	6.60	2.30		8.90	15.05	0.74	0.69	15.09	14.91	2.6
30	4/23/96	8:00	528.00	18.3	119.0	92.0	1.0	6.05	6.60	2.25		8.85	14.90	0.75	0.68	15.09	14.95	2.5
31	4/24/96	8:00	552.00	18.3	119.0	93.0	1.0	6.00	6.62	2.20		8.82	14.82	0.75	0.68	15.13	15.00	2.6
32	4/25/96	8:00	576.00	18.2	119.0	94.0	1.0	6.10	6.60	2.20		8.80	14.90	0.75	0.69	15.09	15.00	2.6
33	4/26/96	8:00	600.00	18.1	120.0	93.0	1.0	5.90	6.70	2.20		8.90	14.80	0.75	0.66	15.31	15.27	2.7
34	4/27/96	8:00	624.00	18.0	120.0	94.0	1.0	6.00	6.55	2.15		8.70	14.70	0.75	0.69	14.97	14.97	2.8
35	4/28/96	8:00	648.00	18.1	120.0	93.0	1.0	6.00	6.65	2.15		8.80	14.80	0.76	0.68	15.20	15.16	2.7
36	4/29/96	8:00	672.00	18.0	120.0	93.0	1.0	5.90	6.65	2.15		8.80	14.70	0.76	0.67	15.20	15.20	2.7
37	4/30/96	8:00	696.00	18.2	120.0	92.0	1.0	5.90	6.70	2.20		8.90	14.80	0.75	0.66	15.31	15.22	2.8
38	5/1/96	8:00	720.00	18.2	121.0	93.0	1.0	5.95	6.60	2.20		8.80	14.75	0.75	0.68	15.09	15.00	2.7
39	5/2/96	8:00	744.00	18.3	122.0	93.0	1.0	6.00	6.60	2.20		8.80	14.80	0.75	0.68	15.09	14.95	2.5
40	5/3/96	8:00	768.00	18.3	123.0	94.0	1.0	6.05	6.65	2.25		8.90	14.95	0.75	0.68	15.20	15.07	2.6
41	5/4/96	8:00	792.00	18.3	123.0	94.0	1.0	6.00	6.60	2.25	**X**	8.85	14.85	0.75	0.68	15.09	14.95	2.5
42	5/5/96	8:00	816.00	18.4	112.0	93.0	1.0	6.00	6.55	2.20		8.75	14.75	0.75	0.69	14.97	14.80	2.7
43	5/6/96	8:00	840.00	18.3	113.0	93.0	1.0	6.00	6.60	2.20		8.80	14.80	0.75	0.68	15.09	14.95	2.6
44																		
45	**Exhibit 9-6 Example Of Field 6 For The Membrane Pilot Data Sheet (page 1 of 4)**																	

	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU
3	**Field E-6: Membrane Performance Data During Operation With The Test Water (continued)**												
4													
5	**SYSTEM**		**SYSTEM**		**SYSTEM**		**SYSTEM**		**SYSTEM**		**SYSTEM**		
6	NDP	MTC_W (Tavg°C)	pH		TDS (mg/L)								
7	(psi)	(gfd/psi)	pH_F (before acid)	pH_F (after acid)	TDS_p	TDS_F (before acid)	TDS_F (after acid)	TDS_C	$TDS_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	TDS_B	R_B (%)
8	99.4	0.156	7.15	6.05	65.0	118.0	147.0	404.0	406.3	-0.58	55.8	328.2	80.2
9	99.3	0.155	7.05	6.10	67.0	122.0	151.0	412.0	414.7	-0.66	55.6	336.0	80.1
10	100.3	0.155	7.10	6.11	65.5	121.0	150.0	408.0	411.2	-0.78	56.3	332.8	80.3
11	100.2	0.159	7.20	6.03	64.0	119.0	150.0	408.0	423.6	-3.83	57.3	340.3	81.2
12	99.6	0.159	7.15	6.00	63.0	119.0	153.0	426.0	437.3	-2.66	58.8	352.0	82.1
13	100.4	0.155	7.15	6.00	64.5	121.0	149.0	405.0	406.3	-0.31	56.7	329.2	80.4
14	100.4	0.152	7.20	6.02	65.0	120.0	149.0	402.0	401.0	0.25	56.4	325.4	80.0
15	100.8	0.151	7.20	6.03	65.0	120.0	152.0	415.0	417.0	-0.47	57.2	337.8	80.8
16	101.3	0.148	7.10	6.03	66.0	118.0	153.0	410.0	410.1	-0.03	56.9	333.6	80.2
17	101.5	0.147	7.15	6.05	67.5	119.0	148.0	400.0	395.1	1.22	54.4	322.3	79.1
18	100.8	0.149	7.15	6.00	66.0	115.0	150.0	411.0	409.8	0.29	56.0	332.3	80.1
19	101.6	0.147	7.00	6.00	68.0	113.0	147.0	395.0	382.2	3.24	53.7	312.4	78.2
20	101.4	0.148	7.05	6.12	67.0	117.0	151.0	398.0	403.0	-1.26	55.6	328.1	79.6
21	100.9	0.152	7.10	6.08	67.0	120.0	150.0	396.0	402.8	-1.71	55.3	326.8	79.5
22	101.8	0.151	7.15	5.98	65.0	120.0	150.0	402.0	410.8	-2.19	56.7	332.2	80.4
23	101.8	0.152	7.20	6.00	65.0	122.0	153.0	415.0	417.0	-0.48	57.5	337.5	80.7
24	100.7	0.150	7.15	6.00	62.0	121.0	149.0	415.0	418.1	-0.75	58.4	338.4	81.7
25	101.3	0.147	7.10	5.99	61.0	121.0	149.0	404.0	405.2	-0.29	59.1	329.0	81.5
26	101.7	0.146	7.10	6.01	61.0	120.0	152.0	411.0	416.9	-1.44	59.9	338.2	82.0
27	101.7	0.146	7.15	6.04	62.0	120.0	153.0	422.0	423.9	-0.46	59.5	344.1	82.0
28	102.4	0.146	7.20	6.03	63.0	119.0	148.0	406.0	403.0	0.74	57.4	327.2	80.7
29	102.4	0.146	7.15	6.00	63.0	118.0	150.0	401.0	399.7	0.34	58.0	325.8	80.7
30	102.0	0.147	7.00	6.00	65.0	118.0	147.0	396.0	387.5	2.14	55.8	316.1	79.4
31	102.4	0.147	7.10	6.03	66.0	116.0	151.0	415.0	406.8	1.98	56.3	330.7	80.0
32	102.9	0.146	7.20	6.00	66.0	119.0	150.0	408.0	402.0	1.47	56.0	327.6	79.9
33	102.8	0.148	7.15	6.01	65.0	120.0	150.0	411.0	408.9	0.52	56.7	331.0	80.4
34	103.2	0.145	7.10	6.03	64.0	120.0	153.0	430.0	424.1	1.36	58.2	343.9	81.4
35	102.8	0.147	7.13	6.11	64.0	121.0	149.0	412.0	411.9	0.02	57.0	333.7	80.8
36	102.8	0.148	7.15	6.00	65.0	120.0	149.0	408.0	408.8	-0.20	56.4	331.0	80.4
37	102.2	0.149	7.20	6.00	63.0	122.0	152.0	415.0	423.0	-1.94	58.6	341.5	81.6
38	103.3	0.145	7.20	6.03	67.0	122.0	153.0	415.0	411.0	0.96	56.2	334.0	79.9
39	104.0	0.144	7.15	5.98	67.0	120.0	148.0	398.0	391.0	1.76	54.7	318.8	79.0
40	104.9	0.144	7.05	5.97	64.5	120.0	150.0	402.0	402.7	-0.17	57.0	327.5	80.3
41	105.0	0.142	7.05	6.00	65.0	119.0	147.0	380.0	387.5	-1.98	55.8	315.9	79.4
42	98.8	0.150	7.15	6.00	65.0	120.0	151.0	405.0	407.0	-0.51	57.0	331.1	80.4
43	99.4	0.150	7.20	5.95	66.0	121.0	150.0	400.0	402.0	-0.50	56.0	327.1	79.8
44													
45	**Exhibit 9-6 Example Of Field 6 For The Membrane Pilot Data Sheet (page 2 of 4)**												

3 **Field E-6: Membrane Performance Data During Operation With The Test Water (continued)**

4 ***Stage 1 Operating Parameters***

	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT
5	STAGE 1		STAGE 1		STAGE 1		STAGE 1		STAGE 1		STAGE 1		STAGE 1		STAGE 1		STAGE 1		STAGE 1		STAGE 1		STAGE 1	
6	P_I	P_C	P_P	Q_p	Qc	Q_F	Q_I	v_c	Recovery	F_W (T^oC)	F_W ($Tavg^oC$)	$\Delta\pi$	NDP	MTC_W ($Tavg^oC$)	pH		TDS (mg/L)							
7	(psi)	(psi)	(psi)	(gpm)	(gpm)	(gpm)	(gpm)	(fps)	(decimal)	(gfd)	(gfd)	(psi)	(psi)	(gfd/psi)	pH_I	pH_C	TDS_p	TDS_I	TDS_C	$TDS_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	C_B	R_B (%)
8	113.0	103.0	1.0	4.50	10.35	8.95	14.85	0.468	0.50	15.43	15.43	2.4	104.6	0.147	6.22	6.45	57.5	254.3	336.0	339.9	-1.15	60.9	297.1	80.6
9	114.0	104.0	1.0	4.55	10.35	8.90	14.90	0.469	0.51	15.60	15.55	2.4	105.6	0.147	6.25	6.41	58.0	253.5	338.0	339.5	-0.43	61.6	296.5	80.5
10	115.0	105.0	1.0	4.60	10.40	9.00	15.00	0.472	0.51	15.77	15.77	2.4	106.6	0.148	6.18	6.39	58.2	253.6	339.5	340.0	-0.16	61.2	296.8	80.4
11	115.0	105.0	1.0	4.60	10.50	9.20	15.10	0.475	0.50	15.77	15.68	2.4	106.6	0.147	6.14	6.42	58.2	254.1	338.6	339.9	-0.39	61.2	297.0	80.4
12	116.0	106.0	1.0	4.55	10.70	9.15	15.25	0.482	0.50	15.60	15.51	2.4	107.6	0.144	6.32	6.44	58.3	254.7	338.0	338.2	-0.06	61.9	296.5	80.3
13	116.0	106.0	1.0	4.50	10.70	9.10	15.20	0.481	0.49	15.43	15.29	2.4	107.6	0.142	6.28	6.37	58.1	253.8	337.1	336.1	0.30	61.0	294.9	80.3
14	116.0	106.0	1.0	4.40	10.60	9.00	15.00	0.475	0.49	15.09	14.95	2.3	107.7	0.139	6.25	6.39	58.6	253.0	333.0	333.7	-0.21	60.7	293.4	80.0
15	116.0	106.0	1.0	4.40	10.50	8.90	14.90	0.472	0.49	15.09	14.95	2.4	107.6	0.139	6.22	6.45	57.5	254.3	336.0	336.8	-0.23	62.2	295.5	80.5
16	117.0	107.0	1.0	4.40	10.55	8.90	14.95	0.473	0.49	15.09	14.91	2.4	108.6	0.137	6.25	6.41	58.0	253.5	338.0	335.1	0.87	62.1	294.3	80.3
17	117.0	107.0	1.0	4.35	10.50	8.75	14.85	0.471	0.50	14.91	14.78	2.4	108.6	0.136	6.18	6.39	58.2	253.6	339.5	334.6	1.46	60.7	294.1	80.2
18	117.0	107.0	1.0	4.40	10.35	8.80	14.75	0.466	0.50	15.09	14.95	2.4	108.6	0.138	6.14	6.42	58.2	254.1	338.6	337.4	0.36	61.2	295.7	80.3
19	117.0	107.0	1.0	4.35	10.40	8.75	14.75	0.467	0.50	14.91	14.83	2.4	108.6	0.136	6.32	6.44	58.3	254.7	338.0	336.8	0.34	60.3	295.8	80.3
20	117.0	107.0	1.0	4.40	10.40	8.80	14.80	0.468	0.50	15.09	15.04	2.4	108.6	0.138	6.28	6.37	58.1	253.8	337.1	336.6	0.15	61.5	295.2	80.3
21	117.0	107.0	1.0	4.50	10.30	8.90	14.80	0.466	0.51	15.43	15.43	2.4	108.6	0.142	6.25	6.39	58.6	253.0	333.0	338.0	-1.49	61.0	295.5	80.2
22	118.0	108.0	1.0	4.45	10.40	8.95	14.85	0.469	0.50	15.26	15.21	2.4	109.6	0.139	6.22	6.45	57.5	254.3	336.0	338.5	-0.75	61.7	296.4	80.6
23	118.0	108.0	1.0	4.45	10.50	9.00	14.95	0.473	0.49	15.26	15.26	2.4	109.6	0.139	6.25	6.41	58.0	253.5	338.0	336.4	0.48	62.1	294.9	80.4
24	118.0	108.0	1.0	4.40	10.45	8.80	14.85	0.470	0.50	15.09	15.00	2.4	109.6	0.137	6.18	6.39	58.2	253.6	339.5	335.9	1.07	60.9	294.7	80.3
25	118.0	108.0	1.0	4.35	10.45	8.80	14.80	0.469	0.49	14.91	14.83	2.4	109.6	0.135	6.14	6.42	58.2	254.1	338.6	335.7	0.87	60.9	294.9	80.3
26	119.0	109.0	1.0	4.35	10.45	8.80	14.80	0.469	0.49	14.91	14.78	2.4	110.6	0.134	6.32	6.44	58.3	254.7	338.0	336.5	0.46	61.6	295.6	80.3
27	119.0	109.0	1.0	4.40	10.45	8.75	14.85	0.470	0.50	15.09	14.95	2.4	110.6	0.135	6.28	6.37	58.1	253.8	337.1	336.2	0.27	62.0	295.0	80.3
28	119.0	109.0	1.0	4.40	10.40	8.80	14.80	0.468	0.50	15.09	14.95	2.4	110.6	0.135	6.25	6.39	58.6	253.0	333.0	335.3	-0.68	60.4	294.1	80.1
29	119.0	109.0	1.0	4.45	10.60	8.90	15.05	0.476	0.50	15.26	15.08	2.4	110.6	0.136	6.22	6.45	57.5	254.3	336.0	336.9	-0.27	61.7	295.6	80.5
30	119.0	109.0	1.0	4.45	10.45	8.85	14.90	0.471	0.50	15.26	15.12	2.4	110.6	0.137	6.25	6.41	58.0	253.5	338.0	336.8	0.36	60.6	295.1	80.4
31	119.0	109.0	1.0	4.40	10.42	8.82	14.82	0.469	0.50	15.09	14.95	2.4	110.6	0.135	6.18	6.39	58.2	253.6	339.5	336.1	1.00	61.5	294.9	80.3
32	119.0	109.0	1.0	4.40	10.50	8.80	14.90	0.472	0.50	15.09	15.00	2.4	110.6	0.136	6.14	6.42	58.2	254.1	338.6	336.2	0.71	61.2	295.1	80.3
33	120.0	110.0	1.0	4.40	10.40	8.90	14.80	0.468	0.49	15.09	15.04	2.4	111.6	0.135	6.32	6.44	58.3	254.7	338.0	337.8	0.06	61.1	296.2	80.3
34	120.0	110.0	1.0	4.30	10.40	8.70	14.70	0.466	0.49	14.74	14.74	2.4	111.6	0.132	6.28	6.37	58.1	253.8	337.1	334.7	0.71	62.0	294.2	80.2
35	120.0	110.0	1.0	4.35	10.45	8.80	14.80	0.469	0.49	14.91	14.87	2.3	111.7	0.133	6.25	6.39	58.6	253.0	333.0	333.9	-0.28	60.7	293.5	80.0
36	120.0	110.0	1.0	4.40	10.30	8.80	14.70	0.464	0.50	15.09	15.09	2.4	111.6	0.135	6.22	6.45	57.5	254.3	336.0	338.4	-0.71	61.4	296.3	80.6
37	120.0	110.0	1.0	4.45	10.35	8.90	14.80	0.467	0.50	15.26	15.17	2.4	111.6	0.136	6.25	6.41	58.0	253.5	338.0	337.6	0.13	61.9	295.5	80.4
38	121.0	111.0	1.0	4.40	10.35	8.80	14.75	0.466	0.50	15.09	15.00	2.4	112.6	0.133	6.18	6.39	58.2	253.6	339.5	336.7	0.83	62.0	295.1	80.3
39	122.0	112.0	1.0	4.40	10.40	8.80	14.80	0.468	0.50	15.09	14.95	2.4	113.6	0.132	6.14	6.42	58.2	254.1	338.6	337.0	0.48	60.7	295.5	80.3
40	123.0	113.0	1.0	4.50	10.45	8.90	14.95	0.472	0.51	15.43	15.29	2.4	114.6	0.133	6.32	6.44	58.3	254.7	338.0	339.3	-0.38	61.1	297.0	80.4
41	123.0	113.0	1.0	4.40	10.45	8.85	14.85	0.470	0.50	15.09	14.95	2.4	114.6	0.130	6.28	6.37	58.1	253.8	337.1	336.2	0.27	60.4	295.0	80.3
42	112.0	102.0	1.0	4.30	10.45	8.75	14.75	0.468	0.49	14.74	14.57	2.3	103.7	0.141	6.25	6.39	58.6	253.0	333.0	333.0	0.00	61.2	293.0	80.0
43	113.0	103.0	1.0	4.40	10.40	8.80	14.80	0.468	0.50	15.09	14.95	2.4	104.6	0.143	6.14	6.42	58.2	254.1	338.6	337.0	0.48	61.2	295.5	80.3

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45 **Exhibit 9-6 Example Of Field 6 For The Membrane Pilot Data Sheet (page 3 of 4)**

Field E-6: Membrane Performance Data During Operation With The Test Water (continued)

Stage 2 Operating Parameters

	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS
5	**STAGE 2**		**STAGE 2**		**STAGE 2**		**STAGE 2**		**STAGE 2**		**STAGE 2**		**STAGE 2**		**STAGE 2**		**STAGE 2**		**STAGE 2**		**STAGE 2**		**STAGE 2**	
6	P_I	P_C	P_P	Q_p	Qc	Q_F	Q_I	v_c	Recovery	F_W (T^oC)	F_W ($Tavg^oC$)	$\Delta\pi$	NDP	MTC_W ($Tavg^oC$)	pH		TDS (mg/L)							
7	(psi)	(psi)	(psi)	(gpm)	(gpm)	(gpm)	(gpm)	(fps)	(decimal)	(gfd)	(gfd)	(psi)	(psi)	(gfd/psi)	pH_I	pH_C	TDS_p	TDS_I	TDS_C	$TDS_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	C_B	R_B (%)
8	103.0	93.0	1.0	2.30	8.05	4.45	10.35	0.683	0.52	15.77	15.77	3.0	94.0	0.168	6.52	6.61	73.6	334.0	404.0	408.4	-1.09	49.9	371.2	80.2
9	104.0	92.0	1.0	2.20	8.15	4.35	10.35	0.687	0.51	15.09	15.04	3.0	94.0	0.160	6.48	6.59	73.3	335.0	412.0	405.6	1.54	51.5	370.3	80.2
10	105.0	93.0	1.0	2.20	8.20	4.40	10.40	0.691	0.50	15.09	15.09	3.0	95.0	0.159	6.53	6.63	73.5	335.9	408.0	406.3	0.41	51.0	371.1	80.2
11	105.0	93.0	1.0	2.40	8.10	4.60	10.50	0.691	0.52	16.46	16.36	3.0	95.0	0.172	6.49	6.60	73.9	335.7	408.0	413.3	-1.31	50.7	374.5	80.3
12	106.0	91.0	1.0	2.40	8.30	4.60	10.70	0.706	0.52	16.46	16.36	3.0	94.5	0.173	6.49	6.59	73.0	333.6	426.0	409.0	4.00	52.3	371.3	80.4
13	106.0	92.0	1.0	2.35	8.35	4.60	10.70	0.707	0.51	16.11	15.97	3.0	95.0	0.168	6.48	6.64	74.1	336.1	405.0	409.9	-1.20	50.3	373.0	80.1
14	106.0	92.0	1.0	2.35	8.25	4.60	10.60	0.700	0.51	16.11	15.97	3.0	95.0	0.168	6.53	6.55	73.4	335.9	402.0	410.7	-2.16	50.7	373.3	80.3
15	106.0	93.0	1.0	2.30	8.20	4.50	10.50	0.694	0.51	15.77	15.63	3.0	95.5	0.164	6.51	6.57	73.2	336.2	415.0	410.0	1.21	51.8	373.1	80.4
16	107.0	93.0	1.0	2.25	8.30	4.50	10.55	0.700	0.50	15.43	15.25	3.0	96.0	0.159	6.50	6.57	73.6	335.9	410.0	407.0	0.74	51.9	371.4	80.2
17	107.0	93.0	1.0	2.25	8.25	4.40	10.50	0.696	0.51	15.43	15.29	3.0	96.0	0.159	6.52	6.61	73.6	334.0	400.0	405.0	-1.25	50.3	369.5	80.1
18	107.0	92.0	1.0	2.25	8.10	4.40	10.35	0.685	0.51	15.43	15.29	3.0	95.5	0.160	6.48	6.59	73.3	335.0	411.0	407.7	0.80	51.1	371.3	80.3
19	107.0	93.0	1.0	2.20	8.20	4.40	10.40	0.691	0.50	15.09	15.00	3.0	96.0	0.156	6.53	6.63	73.5	335.9	395.0	406.3	-2.87	50.0	371.1	80.2
20	107.0	93.0	1.0	2.20	8.20	4.40	10.40	0.691	0.50	15.09	15.04	3.0	96.0	0.157	6.49	6.60	73.9	335.7	398.0	406.0	-2.01	51.1	370.9	80.1
21	107.0	92.0	1.0	2.20	8.10	4.40	10.30	0.683	0.50	15.09	15.09	3.0	95.5	0.158	6.49	6.59	73.0	333.6	396.0	404.4	-2.12	51.4	369.0	80.2
22	108.0	93.0	1.0	2.30	8.10	4.50	10.40	0.687	0.51	15.77	15.72	3.0	96.5	0.163	6.48	6.64	74.1	336.1	402.0	410.5	-2.12	50.6	373.3	80.2
23	108.0	93.0	1.0	2.30	8.20	4.55	10.50	0.694	0.51	15.77	15.77	3.0	96.5	0.163	6.53	6.55	73.4	335.9	415.0	409.5	1.32	52.0	372.7	80.3
24	108.0	91.0	1.0	2.25	8.20	4.40	10.45	0.693	0.51	15.43	15.34	3.0	95.5	0.161	6.51	6.57	73.2	336.2	415.0	408.4	1.60	50.9	372.3	80.3
25	108.0	92.0	1.0	2.20	8.25	4.45	10.45	0.694	0.49	15.09	15.00	3.0	96.0	0.156	6.50	6.57	73.6	335.9	404.0	405.8	-0.45	50.6	370.9	80.2
26	109.0	92.0	1.0	2.20	8.25	4.45	10.45	0.694	0.49	15.09	14.95	3.0	96.5	0.155	6.52	6.61	73.6	334.0	411.0	403.4	1.84	51.6	368.7	80.0
27	109.0	92.0	1.0	2.15	8.30	4.35	10.45	0.696	0.49	14.74	14.61	3.0	96.5	0.151	6.48	6.59	73.3	335.0	422.0	402.8	4.55	52.1	368.9	80.1
28	109.0	93.0	1.0	2.20	8.20	4.40	10.40	0.691	0.50	15.09	14.95	3.0	97.0	0.154	6.53	6.63	73.5	335.9	406.0	406.3	-0.08	50.4	371.1	80.2
29	109.0	93.0	1.0	2.15	8.45	4.45	10.60	0.707	0.48	14.74	14.57	3.0	97.0	0.150	6.49	6.60	73.9	335.7	401.0	402.4	-0.34	50.7	369.1	80.0
30	109.0	92.0	1.0	2.15	8.30	4.40	10.45	0.696	0.49	14.74	14.61	2.9	96.6	0.151	6.49	6.59	73.0	333.6	396.0	401.1	-1.29	50.4	367.4	80.1
31	109.0	93.0	1.0	2.22	8.20	4.42	10.42	0.691	0.50	15.22	15.09	3.0	97.0	0.156	6.48	6.64	74.1	336.1	415.0	407.1	1.91	51.0	371.6	80.1
32	109.0	94.0	1.0	2.20	8.30	4.40	10.50	0.698	0.50	15.09	15.00	3.0	97.5	0.154	6.53	6.55	73.4	335.9	408.0	405.5	0.62	51.1	370.7	80.2
33	110.0	93.0	1.0	2.30	8.10	4.50	10.40	0.687	0.51	15.77	15.72	3.0	97.5	0.161	6.51	6.57	73.2	336.2	411.0	410.9	0.03	51.2	373.6	80.4
34	110.0	94.0	1.0	2.25	8.15	4.40	10.40	0.689	0.51	15.43	15.43	3.0	98.0	0.157	6.50	6.57	73.6	335.9	430.0	408.3	5.05	51.9	372.1	80.2
35	110.0	93.0	1.0	2.30	8.15	4.45	10.45	0.691	0.52	15.77	15.72	3.0	97.5	0.161	6.52	6.61	73.6	334.0	412.0	407.5	1.10	50.6	370.7	80.1
36	110.0	93.0	1.0	2.25	8.05	4.40	10.30	0.681	0.51	15.43	15.43	3.0	97.5	0.158	6.48	6.59	73.3	335.0	408.0	408.1	-0.04	50.8	371.6	80.3
37	110.0	92.0	1.0	2.25	8.10	4.45	10.35	0.685	0.51	15.43	15.34	3.0	97.0	0.158	6.53	6.63	73.5	335.9	415.0	408.8	1.49	51.7	372.4	80.3
38	111.0	93.0	1.0	2.20	8.15	4.40	10.35	0.687	0.50	15.09	15.00	3.0	98.0	0.153	6.49	6.60	73.9	335.7	415.0	406.4	2.07	51.7	371.1	80.1
39	112.0	93.0	1.0	2.20	8.20	4.40	10.40	0.691	0.50	15.09	14.95	3.0	98.5	0.152	6.49	6.59	73.0	333.6	398.0	403.5	-1.39	50.7	368.6	80.2
40	113.0	94.0	1.0	2.15	8.30	4.40	10.45	0.696	0.49	14.74	14.61	3.0	99.5	0.147	6.48	6.64	74.1	336.1	402.0	404.0	-0.50	50.6	370.1	80.0
41	113.0	94.0	1.0	2.20	8.25	4.45	10.45	0.694	0.49	15.09	14.95	3.0	99.5	0.150	6.53	6.55	73.4	335.9	380.0	405.9	-6.82	50.1	370.9	80.2
42	102.0	93.0	1.0	2.25	8.20	4.45	10.45	0.693	0.51	15.43	15.25	3.0	93.5	0.163	6.51	6.57	73.2	336.2	405.0	408.4	-0.83	51.5	372.3	80.3
43	103.0	93.0	1.0	2.20	8.20	4.40	10.40	0.691	0.50	15.09	14.95	3.0	94.0	0.159	6.50	6.57	73.6	335.9	400.0	406.2	-1.56	50.9	371.1	80.2

Exhibit 9-6 Example Of Field 6 For The Membrane Pilot Data Sheet (page 4 of 4)

Field E-7: System And Stage Water Quality For Week 2

System Operating Parameters During Sample Collection

System recovery during sample collection (decimal)	0.75
System feed flow rate during sample collection (gpm)	8.75
System influent flow rate during sample collection (gpm)	14.75

System Permeate, Feed and Concentrate-Waste Water Quality Parameters

Parameter	Units	$C_{p\text{-}sys}$-2	$C_{F\text{-}sys}$-2	$C_{C\text{-}sys}$-2	$C_{C(calc)}$	$Error_{MB}$ (%)	R_F (%)	C_B	R_B (%)
Sampling date	MM/DD/YY	4/12/96	4/12/96	4/12/96	---	---	---	---	---
Sampling time	hh:mm	8:00	8:00	8:00	---	---	---	---	---
Operation time	hh.hh	264.00	264.00	264.00	---	---	---	---	---
pH	---	5.53	5.98	6.30	---	---	---	---	---
Temperature	^oC	18.1	18.1	18.2	---	---	---	---	---
Alkalinity	mg/L as $CaCO_3$	35.0	75.0	202.0	195.0	3.47	53.3	159.4	78.0
Total dissolved solids	mg/L	65.0	150.0	411.0	405.0	1.46	56.7	329.4	80.3
Total hardness	mg/L as $CaCO_3$	108.0	320.0	952.0	956.0	-0.42	66.3	767.4	85.9
Calcium hardness	mg/L as $CaCO_3$	97.0	291.0	860.0	873.0	-1.51	66.7	700.4	86.2
Turbidity	ntu	0.10	0.80	3.00	2.90	3.33	87.5	2.28	95.6
Ammonia	mg NH_3-N / L	1.20	4.80	15.80	15.60	1.27	75.0	12.40	90.3
Total organic carbon	mg/L	0.98	8.00	29.50	29.06	1.49	87.8	22.81	95.7
UV_{254}	cm^{-1}	0.028	0.329	1.250	1.232	1.44	91.5	0.964	97.1
SUVA	L/(mg*m)	2.86	4.11	4.24	---	---	---	---	---
Bromide	µg/L	151.0	250.0	---	547.0	---	39.6	458.9	67.1
SDS-Cl_2 dose	mg/L	1.80	12.00	---	---	---	---	---	---
SDS-Free Cl_2 residual	mg/L	0.90	0.90	---	---	---	---	---	---
SDS-Cl_2 demand	mg/L	0.90	11.10	---	41.70	---	91.9	32.62	97.2
SDS-Chlorination temp.	^oC	18.8	18.8	---	---	---	---	---	---
SDS-Chlorination pH	---	7.86	7.88	---	---	---	---	---	---
SDS-Incubation time	hours	84.5	84.5	---	---	---	---	---	---
SDS-TOX	µg Cl^-/L	52.00	980.00	---	3764.00	---	94.7	2938.24	98.2
SDS-*CHCl3*	µg/L	12.80	162.00	---	609.60	---	92.1	476.84	97.3
SDS-*BDCM*	µg/L	10.30	48.00	---	161.10	---	78.5	127.55	91.9
SDS-*DBCM*	µg/L	9.60	10.00	---	11.20	---	4.0	10.84	11.5
SDS-*CHBr3*	µg/L	0.87	0.45	---	-0.81	---	-93.3	-0.44	299.4
SDS-THM4	µg/L	33.57	220.45	---	781.09	---	84.8	614.80	94.5
SDS-*MCAA**	µg/L	BMRL	4.10	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
SDS-*DCAA**	µg/L	5.63	30.50	---	105.11	---	81.5	82.98	93.2
SDS-*TCAA**	µg/L	8.25	58.90	---	210.85	---	86.0	165.78	95.0
SDS-*MBAA**	µg/L	BMRL	0.97	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
SDS-*DBAA**	µg/L	4.23	2.86	---	-1.25	---	-47.9	-0.03	13775.1
SDS-*BCAA**	µg/L	8.68	21.30	---	59.16	---	59.2	47.93	81.9
SDS-*TBAA*	µg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
SDS-*CDBAA*	µg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
SDS-*DCBAA*	µg/L	NA	NA	---	#VALUE!	---	#VALUE!	#VALUE!	#VALUE!
SDS-HAA5	µg/L	18.11	97.33	---	334.99	---	81.4	264.50	93.2
SDS-HAA6	µg/L	26.79	118.63	---	394.15	---	77.4	312.43	91.4

BMRL = Below Minimum Reporting Level; NA = Not Analyzed; NR = Not Reported

*: These six species make up HAA6, but the other three HAA species, TBAA, CDBAA and DCBAA, should be reported if measured.

Blending Calculations For D-DBP MCLs

THM4 Controls

	Stage 1	Stage 2
Q_p/Q_T (THM4), %	79.4	98.7
SDS-$THM4_b$, µg/L	72.00	36.00
SDS-$HAA5_b$, µg/L	34.40	19.14
SDS-TOX_b, µg Cl^-/L	242.83	64.07
SDS-CD_b, mg/L	3.00	1.03
TOC_b, mg/L	2.42	1.07
$UV_{254\ b}$, cm^{-1}	0.090	0.032
$Bromide_b$, µg/L	171.4	152.3
Alk_b, mg/L $CaCO_3$	43.2	35.5
T-Hd_b, mg/L $CaCO_3$	151.6	110.8
Ca-Hd_b, mg/L $CaCO_3$	136.9	99.5

HAA5 Controls

	Stage 1	Stage 2
Q_p/Q_T (HAA5), %	54.7	88.8
SDS-$THM4_b$, µg/L	118.23	54.54
SDS-$HAA5_b$, µg/L	54.00	27.00
SDS-TOX_b, µg Cl^-/L	472.42	156.14
SDS-CD_b, mg/L	5.52	2.04
TOC_b, mg/L	4.16	1.77
$UV_{254\ b}$, cm^{-1}	0.164	0.062
$Bromide_b$, µg/L	195.9	162.1
Alk_b, mg/L $CaCO_3$	53.1	39.5
T-Hd_b, mg/L $CaCO_3$	204.0	131.8
Ca-Hd_b, mg/L $CaCO_3$	184.9	118.8

Notes:

This field uses the feed and permeate water quality parameters entered above to determine the percentage of total flow that must be treated by the membrane process to meet the Stage 1 and proposed Stage 2 DBP MCLs.

A 10% factor of safety has been applied all the MCLs. i.e., MCLs for Stage 1 are 72 / 54 µg/L and Stage 2 are 36 / 27 µg/L for THM4 and HAA5.

Since either THM4 or HAA5 can control the allowable blend ratio, the blend ratio is calculated for both parameters.

The maximum (Q_p/Q_T) ratio controls the design.

Q_p/Q_T (THM4) is the permeate to total flow ratio for the case where THM4 controls the blend ratio.

Q_p/Q_T (HAA5) is the permeate to total flow ratio for the case where HAA5 controls the blend ratio.

The subscript "b" refers to the blended water quality for a given blend ratio.

If the permeate quality does not meet the MCL prior to blending, then these calculations are meaningless for that MCL.

If the feed water quality meets the MCL, then a negative ratio will be calculated for that MCL.

Exhibit 9-7 Example Of Field 7 For The Membrane Pilot Data Sheet (page 1 of 2)

	DF	DG	DH	DI	DJ	DK	DL	DM
3	**Field E-7: System And Stage Water Quality For Week 2 (continued)**							
4	***Stage 1 Operating Parameters During Sample Collection***							
5	Stage 1 recovery during sample collection (decimal)			0.50				
6	Stage 1 permeate flow rate during sample collection (gpm)			4.35				
7	Stage 1 influent flow rate during sample collection (gpm)			14.75				
8								
9	***Stage 1 Permeate and Influent Water Quality Parameters***							
10	**Parameter**	**Units**	**$C_{p\text{-}s1}$-2**	**$C_{I\text{-}s1}$-2**	**$C_{C(calc)}$**	**R_F (%)**	**C_B**	**R_B (%)**
11	Sampling date	MM/DD/YY	4/12/96	4/12/96	---	---	---	---
12	Sampling time	hh:mm	8:00	8:00	---	---	---	---
13	Operation time	hh.hh	264.00	264.00	---	---	---	---
14	pH	---	5.50	6.10	---	---	---	---
15	Temperature	^oC	18.3	18.3	---	---	---	---
16	Alkalinity	mg/L as $CaCO_3$	8.9	123.0	170.7	88.1	146.9	93.9
17	Total dissolved solids	mg/L	58.2	253.4	335.0	61.2	294.2	80.2
18	Total hardness	mg/L as $CaCO_3$	12.5	210.0	292.6	96.1	251.3	95.0
19	Calcium hardness	mg/L as $CaCO_3$	9.9	166.0	231.3	96.6	198.7	95.0
20	Turbidity	ntu	0.09	1.70	2.37	88.8	2.04	95.6
21	Total organic carbon	mg/L	0.99	17.50	24.41	87.7	20.95	95.3
22	UV_{254}	cm^{-1}	0.023	0.740	1.040	93.0	0.890	97.4
23	SUVA	L/(mg*m)	2.34	4.23	---	---	---	---
24								
25								
26	***Stage 2 Operating Parameters During Sample Collection***							
27	Stage 2 recovery during sample collection (decimal)			0.50				
28	Stage 2 permeate flow rate during sample collection (gpm)			2.20				
29	Stage 2 influent flow rate during sample collection (gpm)			10.40				
30								
31	***Stage 2 Permeate and Influent Water Quality Parameters***							
32	**Parameter**	**Units**	**$C_{p\text{-}s2}$-2**	**$C_{I\text{-}s2}$-2**	**$C_{C(calc)}$**	**R_F (%)**	**C_B**	**R_B (%)**
33	Sampling date	MM/DD/YY	4/12/96	4/12/96	---	---	---	---
34	Sampling time	hh:mm	8:00	8:00	---	---	---	---
35	Operation time	hh.hh	264.00	264.00	---	---	---	---
36	pH	---	5.50	6.10	---	---	---	---
37	Temperature	^oC	18.3	18.3	---	---	---	---
38	Alkalinity	mg/L as $CaCO_3$	11.5	171.3	214.1	84.7	192.7	94.0
39	Total dissolved solids	mg/L	73.3	336.0	406.5	51.1	371.2	80.3
40	Total hardness	mg/L as $CaCO_3$	16.6	293.5	367.8	94.8	330.7	95.0
41	Calcium hardness	mg/L as $CaCO_3$	12.8	232.1	290.9	95.6	261.5	95.1
42	Turbidity	ntu	0.12	2.38	2.99	85.0	2.68	95.5
43	Total organic carbon	mg/L	1.30	24.49	30.71	83.8	27.60	95.3
44	UV_{254}	cm^{-1}	0.029	1.043	1.315	91.2	1.179	97.5
45	SUVA	L/(mg*m)	2.23	4.26	---	---	---	---
46								
47	**Exhibit 9-7 Example Of Field 7 For The Membrane Pilot Data Sheet (page 2 of 2)**							

	HK	HL
3	**Field E-13: Membrane Cost Parameters**	
4	***General Cost Parameters***	
5	**Cost Parameter**	**Parameter value**
6	Capital Recovery Interest Rate (%)	10
7	Capital Recovery Period (years)	20
8	Overhead & Profit Factor (% of construction costs)	5
9	Special Sitework Factor (% of construction costs)	5
10	Construction Contingencies (% of construction costs)	10
11	Engineering Fee Factor (% of construction costs)	10
12	1998 ENR Construction Cost Index (CCI base year 1913)	####
13	1998 Producers Price Index (PPI base year 1967 = 100)	###
14	Labor Rate + Fringe ($/work-hour)	15
15	Labor Overhead Factor (% of labor)	10
16	Electric Rate ($/kW-h)	0.086
17	Fuel Oil Rate ($/gal)	0.89
18	Natural Gas Rate ($/ft^3)	0.0055
19	Current Process Water Rate ($/1000 gal)	0.35
20	Modifications to Existing Plant (% of construction costs)	5
21		
22	**Exhibit 9-8 Example Of Field 13 For The Membrane Pilot Data Sheet**	

Appendix 9a: Membrane Pilot-Scale Equations And Nomenclature

Nomenclature

A	Active membrane area of the full-scale element used in the pilot system **(ft^2)**
BCAA	Bromochloroacetic acid **(μg/L)**
BDCAA	Bromodichloroacetic acid **(μg/L)**
BDCM	Bromodichloromethane **(μg/L)**
BMRL	Below minimum reporting level
$\mathbf{C_b}$	Concentration of a blended sample (i.e., feed:permeate blend)
$\mathbf{C_B}$	Concentration in bulk solution
$\mathbf{C_C}$	Concentration in the concentrate stream (i.e., waste and recycle streams)
$\mathbf{C_{C(calc)}}$	Concentrate concentration based on a mass balance calculation
$\mathbf{C_F}$	Concentration in the feed stream
$\mathbf{C_p}$	Concentration in the permeate stream
$\mathbf{C_{TG}}$	Treatment goal concentration (e.g., 72μg/L for 90% Stage 1 THM4 MCL)
CHBr3	Bromoform **(μg/L)**
CHCl3	Chloroform **(μg/L)**
DBAA	Dibromoacetic acid **(μg/L)**
DBCAA	Dibromochloroacetic acid **(μg/L)**
DBCM	Dibromochloromethane **(μg/L)**
DCAA	Dichloroacetic acid **(μg/L)**
$\mathbf{Error_{MB}}$	Mass balance closure error **(%)**
$\mathbf{F_{\mathit{W}\text{-design}}}$	Design permeate water flux **(gfd)**
$\mathbf{F_{\mathit{W}}(T°C)}$	Water flux at ambient temperature, T°C, **(gfd)**
$\mathbf{F_{\mathit{W}}(Tavg°C)}$	Water flux at the average yearly water temperature, Tavg°C, **(gfd)**
i	The stage number (e.g., stage 1, stage 2, etc.)
$\mathbf{L_s}$	Mechanical pressure losses through a stage **(psi)**
$\mathbf{L_{sys}}$	Flow-weighted pressure losses through the system **(psi)**
LSI	Langelier saturation index
MBAA	Monobromoacetic acid **(μg/L)**
MCAA	Monochloroacetic acid **(μg/L)**
MFI	Modified fouling index
MPFI	Mini plugging factor index
$\mathbf{MTC_{\mathit{W}}}$	Water mass transfer coefficient **(gfd/psi)**
$\mathbf{MTC_{\mathit{W}}(Tavg°C)}$	Water mass transfer coefficient at average temperature, Tavg°C, **(gfd/psi)**
$\mathbf{N_e}$	Number of elements in a single pressure vessel
$\mathbf{N_{v\text{-}s(i)}}$	Number of parallel pressure vessels in stage i
$\mathbf{N_{v\text{-}sys}}$	Total number of pressure vessels in the system
NA	Not analyzed
NDP	Net driving pressure **(psi)**
NR	Not reported
$\mathbf{P_C}$	Pressure of the concentrate stream **(psi)**
$\mathbf{P_I}$	Pressure of the influent stream **(psi)**
$\mathbf{P_{I\text{-}sys}}$	Influent pressure to the system **(psi)**

$\mathbf{P_p}$	Permeate pressure **(psi)**
$\mathbf{P_{p\text{-}sys}}$	Design permeate pressure for the system **(psi)**
$\mathbf{Q_{C\text{-}s}}$	Concentrate flow rate from a stage **(gpm)**
$\mathbf{Q_F}$	Feed flow rate **(gpm)**
$\mathbf{(Q_{F\text{-}e})_{max}}$	Maximum allowable feed flow rate to a single element **(gpm)**
$\mathbf{(Q_{F\text{-}e})_{min}}$	Minimum required feed flow rate to a single element **(gpm)**
$\mathbf{Q_{F\text{-}s}}$	Feed flow rate to a stage **(gpm)**
$\mathbf{(Q_{F\text{-}s})_{end}}$	Feed flow rate into the last element of a stage **(gpm)**
$\mathbf{Q_{F\text{-}sys}}$	Feed flow rate to the system **(gpm)**
$\mathbf{Q_{I\text{-}s}}$	Influent flow rate to a stage **(gpm)**
$\mathbf{Q_{I\text{-}sys}}$	Influent flow rate to the system **(gpm)**
$\mathbf{Q_p}$	Permeate flow rate **(gpm)**
$\mathbf{Q_{p\text{-}e}}$	Permeate flow rate produced by a single membrane element **(gpm)**
$\mathbf{Q_{p\text{-}v}}$	Permeate flow rate produced by a single pressure vessel **(gpm)**
$\mathbf{Q_{p\text{-}s(i)}}$	Permeate flow rate produced by stage i **(gpm)**
$\mathbf{Q_{p\text{-}sys}}$	Permeate flow rate produced by the system **(gpm)**
$\mathbf{(Q_{R\text{-}s})_{max}}$	Maximum allowable concentrate-recycle flow rate through a stage **(gpm)**
$\mathbf{(Q_{R\text{-}s})_{min}}$	Minimum required concentrate-recycle flow rate through a stage **(gpm)**
$\mathbf{Q_{R\text{-}sys}}$	Concentrate-recycle flow rate for the system **(gpm)**
$\mathbf{Q_T}$	Total product flow (i.e., permeate flow plus by-passed feed flow) **(gpm)**
$\mathbf{Q_{W\text{-}sys}}$	Concentrate-waste flow rate from the system **(gpm)**
r	Recycle ratio
$\mathbf{r_b}$	Permeate:total product flow blend ratio (i.e., $\mathbf{Q_p/Q_T}$)
R	Recovery **(decimal fraction)**
$\mathbf{R_{sys}}$	Recovery of the system **(decimal fraction)**
$\mathbf{R_s}$	Recovery of a stage **(decimal fraction)**
$\mathbf{R_B}$	Rejection based on the bulk concentration **(%)**
$\mathbf{R_F}$	Rejection based on the feed concentration **(%)**
$\mathbf{Rej_{TDS}}$	Manufacturer report TDS rejection **(decimal fraction)**
SDI	Silt density index
SDS	Simulated distribution system
SDS-CD	SDS chlorine demand **(mg/L)**
SDS-Cl Dose	SDS chlorine dose **(mg/L)**
SDS-CR	SDS free chlorine residual **(mg/L)**
SDS-HAA5	The sum of five haloacetic acids evaluated under SDS conditions **(μg/L)**
SDS-HAA6	The sum of six haloacetic acids evaluated under SDS conditions **(μg/L)**
SDS-THM4	The sum of four trihalomethanes evaluated under SDS conditions **(μg/L)**
SDS-TOX	Total organic halides evaluated under SDS conditions **(μg $\mathbf{Cl^-}$/L)**
SUVA	Specific ultraviolet absorbance **(L/(mg*m))**
T	Thickness of the mesh feed spacer used in the pilot elements **(ft)**
T°C	Ambient temperature **(°C)**
Tavg°C	Average yearly water temperature at the plant **(°C)**
TBAA	Tribromoacetic acid **(μg/L)**
TCAA	Trichloroacetic acid **(μg/L)**

TDS	Total dissolved solids **(mg/L)**
TDS_B	Total dissolved solids in bulk solution **(mg/L)**
TDS_F	Total dissolved solids in the feed stream **(mg/L)**
TDS_I	Total dissolved solids in the influent stream **(mg/L)**
TDS_p	Total dissolved solids in the permeate stream **(mg/L)**
TDS_C	Total dissolved solids in the concentrate stream **(mg/L)**
TOC	Total organic carbon **(mg/L)**
UV_{254}	Ultra-violet absorbance at 254 nm **(cm^{-1})**
v_c	Cross-flow velocity **(fps)**
w	Total width of all membrane envelopes in a single pilot element **(ft)**
$\Delta\pi$	Estimate of the osmotic pressure gradient **(psi)**
$\Delta\pi_i$	Osmotic pressure gradient for stage i **(psi)**
ΔP_s	Estimated pressure losses due to stage hardware **(psi)**
ΔP_e	Estimated pressure losses through a single pilot element **(psi)**

2-Stage Membrane Pilot System Design Calculations

Temperature Normalized MTC_W (Example cell: H6)

$$MTC_W(Tavg°C) = MTC_W(T°C) \times 1.03^{(Tavg°C - T°C)} \quad \textbf{(9a.1)}$$

Permeate Flow Rate per Element (Example cell: H14)

$$Q_{p\text{-}e} = F_{W\text{-design}} \times A / 1440 \text{ (min per day)} \quad \textbf{(9a.2)}$$

Permeate Flow Rate per Pressure Vessel (Example cell: H15)

$$Q_{p\text{-}v} = Q_{p\text{-}e} \times N_e \quad \textbf{(9a.3)}$$

Permeate Flow Rate Produced by Stage 1 (Example cell: H16)

$$Q_{p\text{-}s(1)} = Q_{p\text{-}v} \times N_{v\text{-}s(1)} \quad \textbf{(9a.4)}$$

Permeate Flow Rate Produced by Stage 2 (Example cell: H17)

$$Q_{p\text{-}s(2)} = Q_{p\text{-}v} \times N_{v\text{-}s(2)} \quad \textbf{(9a.5)}$$

Permeate Flow Rate Produced by the System (Example cell: H18)

$$Q_{p\text{-}sys} = Q_{p\text{-}s(1)} + Q_{p\text{-}s(2)} \quad \textbf{(9a.6)}$$

Feed Flow Rate to System (Example cell: H19)

$$Q_{F\text{-}sys} = Q_{p\text{-}sys} / R_{sys} \quad \textbf{(9a.7)}$$

Concentrate-Waste Flow Rate from System (Example cell: H20)

$$Q_{W\text{-}sys} = Q_{F\text{-}sys} - Q_{p\text{-}sys} \quad \textbf{(9a.8)}$$

Feed Flow Rate at the End of a Stage (Example cell: H23, H24)

$$(Q_{F\text{-}s})_{end} = Q_{F\text{-}s} - N_{v\text{-}s} \times Q_{p\text{-}e} \times (N_e - 1) \quad \textbf{(9a.9)}$$

Minimum Recycle Flow Rate to a Stage (Example cells: H27, H28)

$$(Q_{R\text{-}s})_{min} = N_{v\text{-}s} \times (Q_{F\text{-}e})_{min} - (Q_{F\text{-}s})_{end} \quad \textbf{(9a.10)}$$

Maximum Recycle Flow Rate to a Stage (Example cells: H33, H34)

$$(Q_{R\text{-}s})_{max} = N_{v\text{-}s} \times (Q_{F\text{-}e})_{max} - Q_{F\text{-}s} \quad \textbf{(9a.11)}$$

Influent Flow Rate to the System (Example Cell: H40)

$$Q_{I\text{-}sys} = Q_{F\text{-}sys} + Q_{R\text{-}sys} \quad \textbf{(9a.12)}$$

Recycle Ratio (Example cell: H41)

$$r = Q_{R\text{-}sys} / Q_{F\text{-}sys} \quad \textbf{(9a.13)}$$

Concentrate Flow Rate from a Stage (Example cells: H48, H51)

$$Q_{C\text{-}s} = Q_{I\text{-}s} - Q_{p\text{-}s} \quad \textbf{(9a.14)}$$

Estimate of Required Influent Pressure

Mechanical Pressure Losses per Stage (Example cell: H63)

$$\mathbf{L_s = \Delta P_s + N_e \times \Delta P_e} \qquad \textbf{(9a.15)}$$

Pressure Required for Permeation (Example cell: H64)

$$\mathbf{NDP = F_{\mathit{W}\text{-design}} / MTC_{\mathit{W}}(Tavg°C)} \qquad \textbf{(9a.16)}$$

Flow Weighted System Pressure Losses (Example cell: H65)

$$\mathbf{L_{sys} = \left(L_s \times \sum_{i=1}^{n} \frac{Q_{p-s(i)}}{Q_{p-sys}} \times (i - 0.5)\right) + \left(\sum_{i=1}^{n} \frac{Q_{p-s(i)}}{Q_{p-sys}} \times \Delta\pi_i\right)} \qquad \textbf{(9a.17)}$$

Design Influent Pressure (Example cell: H66)

$$\mathbf{P_{I\text{-}sys} = NDP + L_{sys} + P_{p\text{-}sys}} \qquad \textbf{(9a.18)}$$

Membrane Operating Parameters and Productivity

System Feed Flow Rate (Example cells: AB8:AB43)

$$\mathbf{Q_{F\text{-}sys} = Q_{p\text{-}sys} + Q_{W\text{-}sys}} \qquad \textbf{(9a.19)}$$

System Influent Flow Rate (Example cells: AC8:AC43)

$$\mathbf{Q_{I\text{-}sys} = Q_{F\text{-}sys} + Q_{R\text{-}sys}} \qquad \textbf{(9a.20)}$$

System Recovery (Example cells: AD8:AD43)

$$\mathbf{R_{sys} = Q_{p\text{-}sys} / Q_{F\text{-}sys}} \qquad \textbf{(9a.21)}$$

System Recycle Ratio (Example cells: AE8:AE43)

$$\mathbf{r = Q_{R\text{-}sys} / Q_{F\text{-}sys}} \qquad \textbf{(9a.22)}$$

System Water Flux at Ambient Temperature (Example cells: AF8:AF43)

$$\mathbf{F_{\mathit{W}}(T°C) = (Q_{p\text{-}s} / (A \times N_{v\text{-}sys} \times N_e)) \times 1440 \text{ (min per day)}} \qquad \textbf{(9a.23)}$$

Stage Feed Flow Rate (Example cells: BB8:BB43, CA8:CA43)

$$\mathbf{Q_{F\text{-}s} = Q_{p\text{-}s} + Q_{C\text{-}s} - Q_{R\text{-}sys}} \qquad \textbf{(9a.24)}$$

Stage Influent Flow Rate (Example cells: BC8:BC43, CB8:CB43)

$$\mathbf{Q_{I\text{-}s} = Q_{p\text{-}s} + Q_{C\text{-}s}} \qquad \textbf{(9a.25)}$$

Stage Cross-Flow Velocity (Example cells: BD8:BD43, CC8:CC43)

$$\mathbf{v_{c\text{-}s} = (0.5 \times (Q_{I\text{-}s} + Q_{C\text{-}s}) / (N_{v\text{-}s} \times w \times T)) \times 2.228 \times 10^{-3} \text{ (cfs per gpm)}} \qquad \textbf{(9a.26)}$$

Stage Recovery (Example cells: BE8:BE43, CD8:CD43)

$$\mathbf{R_s = Q_{p\text{-}s} / Q_{F\text{-}s}} \qquad \textbf{(9a.27)}$$

Stage Water Flux at Ambient Temperature (Example cells: BF8:BF43, CE8:CE43)

$$\mathbf{F_W(T°C) = (Q_{p\text{-}s} / (A \times N_{v\text{-}s} \times N_e)) \times 1440\ (min\ per\ day)} \quad \textbf{(9a.28)}$$

Flux at Average Water Temperature (Example cells: AG8:AG43, BG8:BG43, CF8:CF43)

$$\mathbf{F_W(Tavg°C) = F_W(T°C) \times 1.03^{(Tavg°C\ -\ T°C)}} \quad \textbf{(9a.29)}$$

Estimate of Osmotic Pressure Gradient (Example cells: AH8:AH43, BH8:BH43, CG8:CG43)

$$\Delta\pi = \mathbf{0.01 \times (TDS_B - TDS_p)} \quad \textbf{(9a.30)}$$

Net Driving Pressure (Example cells: AI8:AI43, BI8:BI43, CH8:CH43)

$$\mathbf{NDP = ((P_I + P_C)/2) - P_p - \Delta\pi} \quad \textbf{(9a.31)}$$

Water Mass Transfer Coefficient at Average Temperature (Example cells: AJ8:AJ43, BJ8:BJ43, CI8:CI43)

$$\mathbf{MTC_W(Tavg°C) = F_W(Tavg°C) / NDP} \quad \textbf{(9a.32)}$$

Water Quality Analysis

SDS-Chlorine Demand (Example cells: CW28:CX28, DQ28:DR28, EK28:EL28, FE28:FF28, FY28:FZ28, GS28:GT28)

$$\mathbf{(SDS\text{-}CD) = (SDS\text{-}Cl\ Dose) - (SDS\text{-}CR)} \quad \textbf{(9a.33)}$$

SDS-HAA5 (Example cells: CW47:CX47, DQ47:DR47, EK47:EL47, FE47:FF47, FY47:FZ47, GS47:GT47)

$$\mathbf{SDS\text{-}HAA5 = MCAA + DCAA + TCAA + MBAA + DBAA} \quad \textbf{(9a.34)}$$

SDS-HAA6 (Example cells: CW48:CX48, DQ48:DR48, EK48:EL48, FE48:FF48, FY48:FZ48, GS48:GT48)

$$\mathbf{SDS\text{-}HAA6 = MCAA + DCAA + TCAA + MBAA + DBAA + BCAA} \quad \textbf{(9a.35)}$$

SDS-THM4 (Example cells: CW37:CX37, DQ37:DR37, EK37:EL37, FE37:FF37, FY37:FZ37, GS37:GT37)

$$\mathbf{SDS\text{-}THM4 = CHCl3 + BDCM + DBCM + CHBr3} \quad \textbf{(9a.36)}$$

Calculated Concentrate Concentration (Example cells: AQ8:AQ43, BP8:BP43, CO8:CO43, CZ16:CZ48, DJ16:DJ44, DT16:DT48, ED16:ED44, EN16:EN48, EX16:EX44, FH16:FH48, FR16:FR44, GB16:GB48, GL16:GL44, GV16:GV48, HF16:HF44)

$$\mathbf{C_{C(calc)} = (C_F - R \times C_p) / (1\text{-}R)} \quad \textbf{(9a.37)}$$

Mass Balance Closure Error (Example cells: AR8:AR43, BQ8:BQ43, CP8:CP43, DA16:DA23, DU16:DU23, EO16:EO23, FI16:FI23, GC16:GC23, GW16:GW23)

$$\mathbf{Error_{MB} = ((C_C - C_{C(calc)}) / C_C) \times 100\%} \quad \textbf{(9a.38)}$$

Feed Rejection (Example cells: AS8:AS43, BR8:BR43, CQ8:CQ43, DB16:DB48, DK16:DK44, DV16:DV48, EE16:EE44, EP16:EP48, EY16:EY44, FJ16:FJ48, FS16:FS44, GD16:GD48, GM16:GM44, GX16:GX48, HG16:HG44)

$$\mathbf{R_F = ((C_F - C_p)/C_F) \times 100\%} \qquad \mathbf{(9a.39)}$$

Bulk Concentration (Example cells: AT8:AT43, BS8:BS43, CR8:CR43, DC16:DC48, DL16:DL44, DW16:DW48, EF16:EF44, EQ16:EQ48, EZ16:EZ44, FK16:FK48, FT16:FT44, GE16:GE48, GN16:GN44, GY16:GY48, HH16:HH44)

$$\mathbf{C_B = (C_F \times Q_F + C_C \times (2 \times Q_I - Q_F))/2 \times Q_I} \qquad \mathbf{(9a.40)}$$

Bulk Rejection (Example cells: AU8:AU43, BT8:BT43, CS8:CS43, DD16:DD48, DM16:DM44, DX16:DX48, EG16:EG44, ER16:ER48, FA16:FA44, FL16:FL48, FU16:FU44, GF16:GF48, GO16:GO44, GZ16:GZ48, HI16:HI44)

$$\mathbf{R_B = ((C_B - C_p)/C_B) \times 100\%} \qquad \mathbf{(9a.41)}$$

Blend Ratio (Example cells: CV55:DA55, DP55:DU55, EJ55:EO55, FD55:FI55, FX55:GC55, GR55:GW55)

$$\mathbf{r_b = Q_p/Q_T = (C_F - C_{TG})/(C_F - C_p)} \qquad \mathbf{(9a.42)}$$

C_{TG}(THM4, Stage 1) = 72 μg/L; C_{TG}(HAA5, Stage 1) = 54 μg/L;
C_{TG}(THM4, Stage 2) = 36 μg/L; C_{TG}(HAA5, Stage 2) = 27 μg/L

Blended Water Quality (Example cells: CV56:DA65, DP56:DU65, EJ56:EO65, FD56:FI65, FX56:GC65, GR56:GW65)

$$\mathbf{C_b = r_b \times (C_p - C_F) + C_F} \qquad \mathbf{(9a.43)}$$

SUVA (Example cells: CW24:CY24, DH23:DI23, DQ24:DS24, EB23:EC23, EK24:EM24, EV23:EW23, FE24:FG24, FP23:FQ23, FY24:GA24, GJ23:GK23, GS24:GU24, HD23:HE23)

$$\mathbf{SUVA = (UV_{245}/TOC) \times 100 (cm/m)} \qquad \mathbf{(9a.44)}$$

10.0 Format For The Hard-Copy *Treatment Study Summary Report*

The purpose of the previously described *Data Collection Spreadsheets* is to report the majority of the treatment study data to EPA in an electronic format. However, several important details of the treatment study cannot be captured in the *Data Collection Spreadsheets* such as the study design, design information for the pretreatment processes used during the study, QA/QC information, etc. **The purpose of the *Treatment Study Summary Report* is to capture the above mentioned details and succinctly describe them using tabular and graphical presentations when possible.** This section provides guidance on the preparation of the report. The format presented herein does not need to be followed exactly if another method of organization or presentation can be used to communicate the same information.

Section 10.1 describes a proposed outline for the *Treatment Study Summary Report,* and Sections 10.2 through 10.7 provide guidance on the preparation of each major section of the proposed outline. When necessary, details specific to a particular type of study (i.e., GAC or membranes) are discussed.

Questions regarding the format for the *Treatment Study Summary Report* should be directed to the Safe Drinking Water Hotline at 800-426-4791 or the ICR Treatment Studies Coordinator at 513-569-7131.

10.1 Outline For The *Treatment Study Summary Report*

This section presents the preferred outline for the *Treatment Study Summary Report*. This report should describe the necessary details as succinctly as possible using tables, graphs and a minimal amount of text. The preferred outline is as follows:

Cover Page
I. Conclusions And Recommendations
II. Background Information
- ♦ Treatment Plant Description
  - Treatment plant schematic
  - Treatment plant design information
  - Treatment challenges facing plant
- ♦ Tabular summary of source/finished water quality

III. Materials And Methods
- ♦ Pretreatment Processes To The Advanced Treatment Process
  - Schematics of pretreatment processes
  - Design data for each pretreatment process
- ♦ Advanced Treatment Process Information
  - Schematics and descriptions of the process equipment used to investigate the advanced treatment process
  - Design data for the advanced treatment process
  - Procedures specific to the treatment study
- ♦ Experimental Design
- ♦ Analytical Methods

IV. Results And Discussion

- ♦ Problems Encountered
- ♦ Water Quality Data
  - Water quality of pretreated influent
  - DBP data and data analysis
- ♦ Impact Of Seasonal Variability
- ♦ Impact Of Specific Variables On Performance (If investigated)
- ♦ Cost Information And Analysis (If cost analyses are performed)
- ♦ Summary Of Significant Results (Specific to Membranes or GAC)

V. QA/QC Summary

The remaining six subsections of Section 10.0 provide a detailed description of the information that is to be included under each main heading of this outline.

10.2 Cover Page

A cover page should be included with each *Treatment Study Summary Report*, and an example cover page is shown in Figure 10-1. The cover page should contain the following information:

- The technology investigated during the study (i.e, GAC or membranes) and the scale of the study (i.e., full-, pilot- or bench-scale).
- The starting and completion dates for the study.
- The PWS name, PWSID#, mailing address, telephone number and fax number.
- The plant name and plant ICR#.
- The name and address of the organization that prepared the *Final Treatment Study Report* (if other than the PWS).
- The date of the *Final Treatment Study Report*.
- The number of *Data Collection Spreadsheet* diskettes submitted with the *Final Treatment Study Report*.

10.3 Section I: Conclusions And Recommendations

The first section of the *Treatment Study Summary Report* should briefly describe the main conclusions drawn from the treatment study, as well as any recommendations regarding the use of the advanced treatment process to control DBPs. The conclusions and recommendations should focus on the technical and economic feasibility of implementing the advanced treatment process investigated during the study to control the concentration of DBPs formed in the distribution system. Other water quality goals and operational concerns can also be addressed in this section, such as compliance with other regulations, disposal of residuals, etc.

ICR Treatment Study Summary Report

Evaluation of Membrane Technology Using the Single Element Bench-Scale Test for Compliance with the Information Collection Rule

Conducted during the period of August 15, 1997 through June 2, 1998

Prepared by:
XYZ Consultants
Street Address
City, State Zip

In July 1998

For:
Public Water System Name, PWSID#
Street Address
City, State Zip
Telephone Number
Fax Number

Plant Name, Plant ICR#

Attachments: 3 diskettes containing the *Data Collection Spreadsheets*

Figure 10-1 Example Cover Page For The ICR *Treatment Study Summary Report*

10.4 Section II: Background Information

The purpose of the Background Section is to provide basic information about the treatment plant and source/finished water quality as well as a brief description of the treatment challenges facing the plant. A simple schematic of the existing treatment plant, such as the example shown in Figure 10-2, should be presented as part of the background information. If the treatment plant is conducting 18-months of DBP/micro monitoring under the ICR, then a schematic similar to the one used to develop the initial sampling plan can be submitted. Alternatively, the plant may use an existing plant schematic or develop a new schematic. The schematic should indicate all points of chemical addition and washwater return, as well as the sampling point for the influent to the treatment study.

The Background Section must also include a summary of basic engineering data for each unit process. If the treatment plant is using the *ICR Water Utility Database System* (EPA 814-B-96-004, April 1996) to report the results from the 18-months of DBP/micro monitoring, then the plant can submit the data from report A.2, Design Plant Parameters, and report A.3, Design Plant Chemical Parameters. Appendix A of the *ICR Sampling Manual* (EPA 814-B-96-001, April, 1996) shows examples of these reports. If the treatment plant is not using the *Water Utility Database System*, or does not have access to the specified reports, then a tabular summary of the engineering and chemical design parameters for each unit process will need to be generated. An example of a tabular summary of treatment plant design data is presented in Table 10-1.

A tabular summary of the average source and finished water quality should also be included in the Background Section. This summary should reflect yearly averages for recent water quality analyses. In the example shown in Table 10-2, the yearly average, standard deviation, maximum yearly value and minimum yearly value are shown for the following source water quality parameters: temperature, pH, turbidity, alkalinity, total hardness, calcium hardness, TOC, UV_{254} and bromide. In Table 10-3, the yearly average, standard deviation, maximum yearly value and minimum yearly value are shown for the following finished water quality parameters: temperature, pH, turbidity, TOC and distribution system THM4. If applicable, the results from the 18 months of DBP/micro monitoring can be used to generate these summary tables. **Note that this is not a requirement to conduct additional source or finished water monitoring, rather it is a request for recent water quality data for parameters that are routinely monitored at the plant.**

10.5 Section III: Materials And Methods

The purpose of the Materials And Methods Section is to describe the pretreatment to the advanced process, the equipment used for the pilot- or bench-scale study, the experimental design, and the analytical methods used during the study.

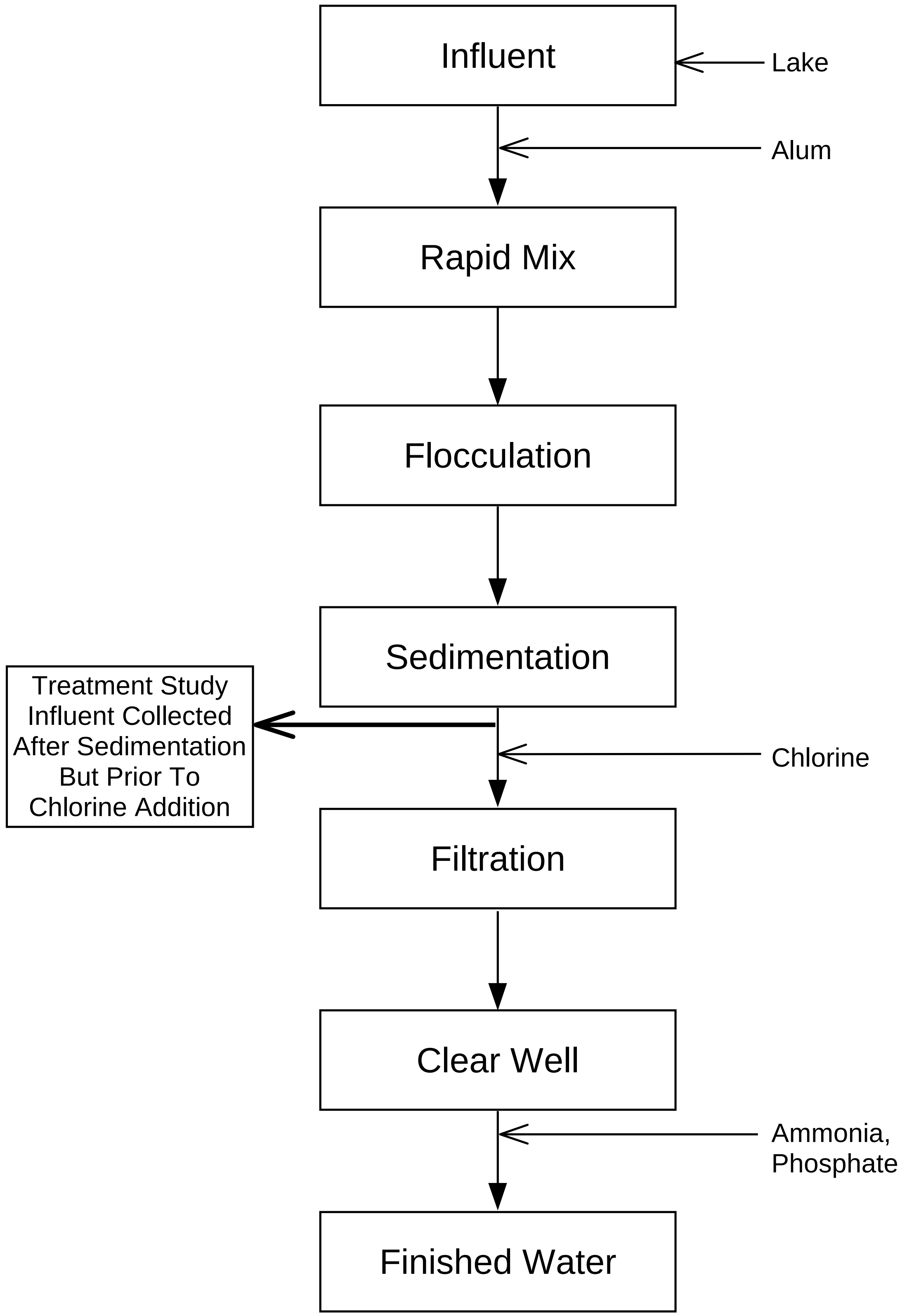

Figure 10-2 Example Schematic Of An Existing Full-Scale Treatment Plant

Unit Process	Process Description
Rapid Mix	Type of Mixer: Mechanical Baffling Type: Unbaffled - Mixed tank Liquid Volume (gal): 100,000 Mean Velocity Gradient (sec^{-1}): 100.0 Coagulant Addition: Alum Coagulant Dose (mg/L): 10 Acid Addition: Sulfuric Acid Acid Dose (mg/L): 5
Flocculation	Type of Mixer: Mechanical Liquid Volume (gal): 1,000,000 Short Circuiting Factor: 0.5 Baffling Type: Poor - Inlet/Outlet Only Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec^{-1}): 30.0 Stage Liquid Volume (gal): 500,000 Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec^{-1}): 20.0 Stage Liquid Volume (gal): 500,000
Sedimentation	Surface Area (ft^2): 100,000 Liquid Volume (gal): 1,000,000 Baffling Type: Average - In/Out/Intermediate Short Circuiting Factor: Tube Settler Surface Area (ft^2): Tube Settler Brand Name:
Filtration	Surface Area (ft^2): 100,000 Liquid Volume (gal): 1,000,000 Total Media Depth (in): 24 Media Type: Dual - Anthracite/Sand Minimum Water Depth to Top of Media (in): 8.0 Depth From Top of Media to Top of Backwash Trough (in): 6.0
Disinfection	Chemical Type: Chlorine Gas Measured as: Cl_2 Dose Rate (mg/L): 3.00
Clear Well	Surface Area (ft^2): 100,000 Liquid Volume (gal): 1,000,000 Baffling Type: Superior - Serpentine Short Circuiting Factor: Covered Contactor: Yes Corrosion Control Chemical: Sodium Hexametaphosphate Corrosion Inhibitor Dose: 4 mg/L

Table 10-1 Example Tabular Summary Of Treatment Plant Design Data
See Appendix A of the *ICR Sampling Manual* for additional examples.

Water Quality Parameter	Average Yearly Concentration	Standard Deviation	Maximum Yearly Value	Minimum Yearly Value
Temperature (°C)	15.5	4.7	28.2	4.0
pH	7.64	0.42	8.33	7.18
Turbidity (ntu)	45.6	4.3	564	38.4
Alkalinity (mg/L as $CaCO_3$)	81.0	5.2	101	59.7
Calcium Hardness (mg/L $CaCO_3$)	112.3	8.6	138	98.5
Total Hardness (mg/L $CaCO_3$)	129.4	9.3	151	108
TOC (mg/L)	8.39	1.42	10.8	6.58
UV_{254} (cm^{-1})	0.286	0.096	0.306	0.251
Bromide (μg/L)	28.6	4.2	48.5	19.6

Table 10-2 Example Tabular Summary Of Source Water Quality

Water Quality Parameter	Average Yearly Concentration	Standard Deviation	Maximum Yearly Value	Minimum Yearly Value
Temperature (°C)	15.5	4.7	28.2	4.0
pH	8.27	0.31	8.79	7.61
Turbidity (ntu)	0.34	0.07	0.47	0.18
TOC (mg/L)	3.45	0.66	4.62	2.40
Distribution System THM4 (μg/L)	32.6	5.7	58.9	18.4

Table 10-3 Example Tabular Summary Of Finished Water Quality

Simple schematics should be provided for all full-scale, pilot-scale and bench-scale pretreatment processes used prior to the advanced treatment process under investigation (i.e., prior to GAC or membranes). An example schematic of a pretreatment system is shown in Figure 10-3. If multiple pretreatment systems are used, a separate schematic must be supplied for each pretreatment system. Furthermore, when multiple pretreatment systems are used during a study, the experimental design should indicate which pretreatment system was used during different periods of the study. Design information for all of the pretreatment processes used in the study should be presented in tabular format similar to that shown in Table 10-4.

Schematics of the process equipment used to simulate the advanced treatment process should also be included in this section. An example of a schematic for an RBSMT system is shown in Figure 10-4. The schematic of the advanced treatment process can also be incorporated into the pretreatment process schematic to depict the complete system (i.e., the schematics in Figures 10-3 and 10-4 could be combined).

This section must also describe any procedures or methods specific to the study being conducted, as well as any deviations from the methods specified in the *ICR Manual for Bench- and Pilot-Scale Treatment Studies*. Some examples of these procedures/deviations include:

- The cleaning procedure(s) used during a membrane study.
- The method used to load carbon into a RSSCT column.
- The protocol used to demonstrate no leaching of TOC from a 6 inch PVC GAC column.
- The procedure used to mitigate headloss buildup in a RSSCT column.

The Materials And Methods Section should also include a discussion of the experimental design, including a description of the primary variables investigated during the study and the rational behind the study design. Tables 10-5 through 10-9 present simple examples of experimental designs for different types of treatment studies. Table 10-5 presents an example experimental design for an RBSMT study in which seasonal variability, permeate water flux and recovery were investigated for two different membranes. Table 10-6 presents an example experimental design for a SEBST study in which seasonal variability and two pretreatment processes were investigated for two different membranes. Table 10-7 presents an example experimental design for a pilot-scale membrane study in which seasonal variability and two recoveries were investigated for one membrane. Table 10-8 presents an example experimental design for a RSSCT study in which seasonal variability and two pretreatment processes were investigated at two empty bed contact times. Table 10-9 presents an example experimental design for a pilot-scale GAC study in which seasonal variability was investigated at two empty bed contact times.

In each of the example experimental designs described above, the requirements of the ICR have been met. For example, the RBSMT study design lists the four recoveries that must be investigated and the RSSCT study design lists the two empty bed contact times that must be evaluated. Additionally, the experimental designs list other variables that were investigated such as pretreatment processes or permeate fluxes. Finally, the example designs indicate the number of quarters used to evaluate the impact of seasonal changes in water quality on process performance.

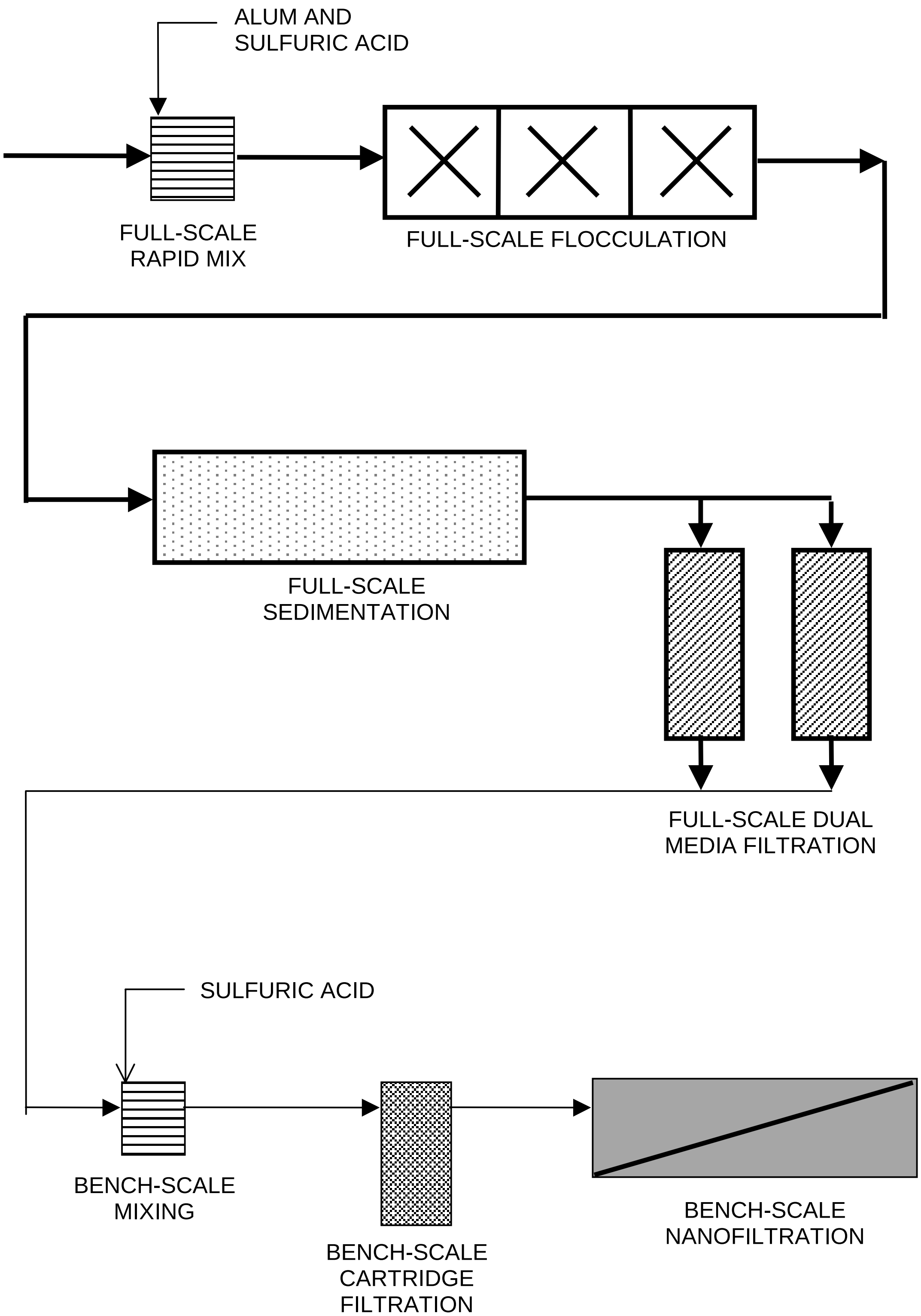

Figure 10-3 Example Schematic Of A Pretreatment System Used Prior To Bench-Scale Nanofiltration

Unit Process	**Process Description**
Rapid Mix (Full-Scale)	Type of Mixer: Mechanical Baffling Type: Unbaffled - Mixed tank Liquid Volume (gal): 100,000 Mean Velocity Gradient (sec^{-1}): 100.0 Coagulant Addition: Alum Coagulant Dose (mg/L): 18.5 Acid Addition: Sulfuric Acid Acid Dose (mg/L): 7.5
Flocculation (Full-Scale)	Type of Mixer: Mechanical Liquid Volume (gal): 1,000,000 Short Circuiting Factor: 0.5 Baffling Type: Poor - Inlet/Outlet Only Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec^{-1}): 30.0 Stage Liquid Volume (gal): 500,000 Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec^{-1}): 20.0 Stage Liquid Volume (gal): 500,000
Sedimentation (Full-Scale)	Surface Area (ft^2): 100,000 Liquid Volume (gal): 1,000,000 Baffling Type: Average - In/Out/Intermediate Short Circuiting Factor: Tube Settler Surface Area (ft^2): Tube Settler Brand Name:
Filtration (Full-Scale)	Surface Area (ft^2): 100,000 Liquid Volume (gal): 1,000,000 Total Media Depth (in): 24 Media Type: Dual - Anthracite/Sand Minimum Water Depth to Top of Media (in): 8.0 Depth From Top of Media to Top of Backwash Trough (in): 6.0
Scale Control (Bench-Scale)	Chemical Type: Sulfuric Acid Adjusted pH: 5.5 Dose Rate (mg/L): 5.0
Cartridge Filtration (Bench-Scale)	Surface Area (ft^2): 12 Nominal Pore size (μm): 5.0 Filter Material: Polypropylene Filter Life (gallons of processed water): 500

Table 10-4 Example Tabular Summary Of Pretreatment Design Data

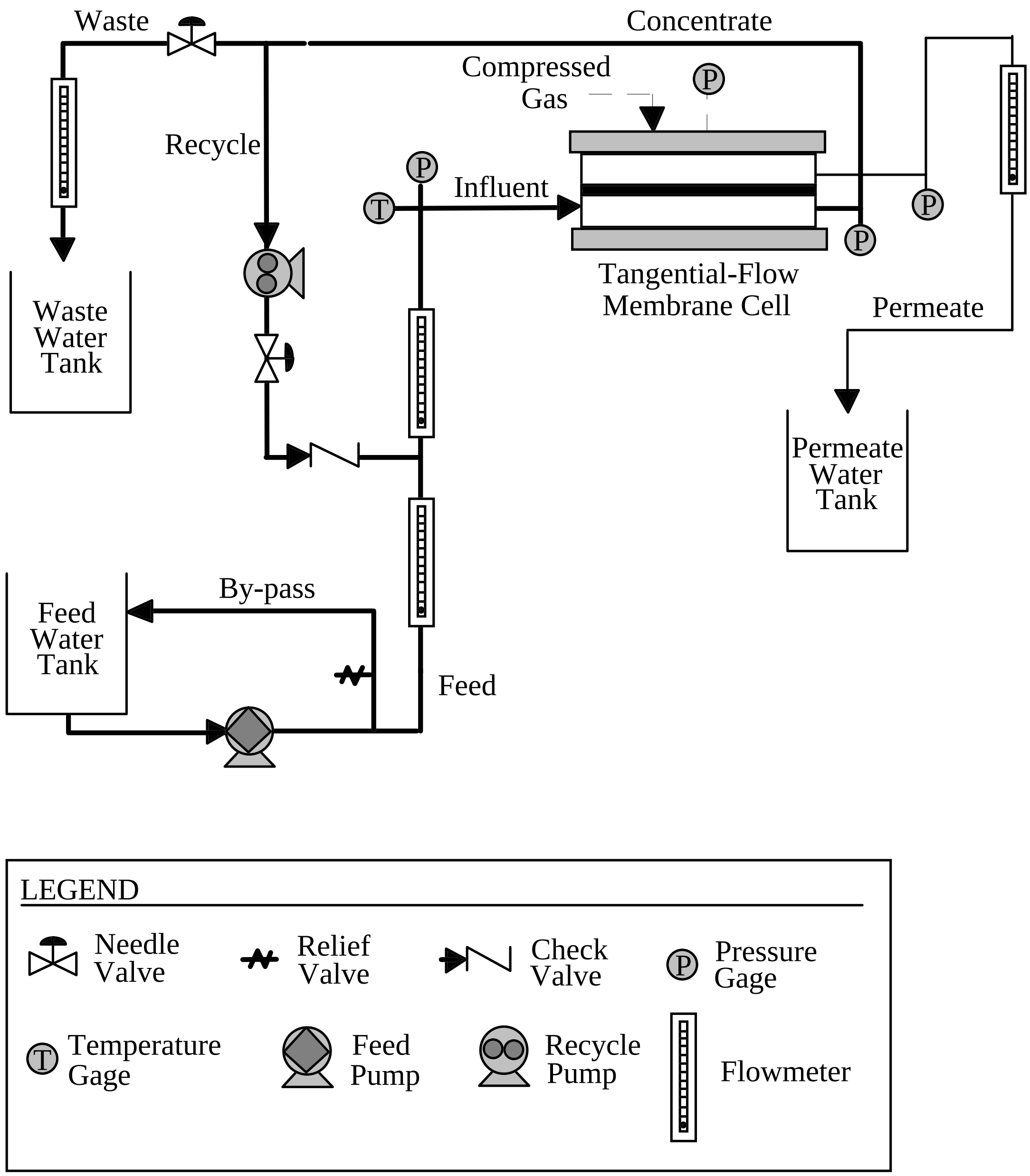

Figure 10-4 Example Schematic Of A Bench-Scale Membrane Testing System

Season	Membrane	Pretreatment	Water Flux, gfd	Recovery, %
Spring	Membrane A	Conventional filtration w/acid	10	30, 50, 70 & 90
Spring	Membrane B	Conventional filtration w/acid	10	30, 50, 70 & 90
Spring	Membrane A	Conventional filtration w/acid	20	30, 50, 70 & 90
Spring	Membrane B	Conventional filtration w/acid	20	30, 50, 70 & 90
Autumn	Membrane A	Conventional filtration w/acid	10	30, 50, 70 & 90
Autumn	Membrane B	Conventional filtration w/acid	10	30, 50, 70 & 90
Autumn	Membrane A	Conventional filtration w/acid	20	30, 50, 70 & 90
Autumn	Membrane B	Conventional filtration w/acid	20	30, 50, 70 & 90

Table 10-5 Example Of An Experimental Design Summary For A RBSMT Study

Season	Membrane	Pretreatment	Water Flux, gfd	Recovery, %
Spring	Membrane A	Conventional filtration w/acid	15	75
Spring	Membrane B	Conventional filtration w/acid	15	75
Spring	Membrane A	Microfiltration w/acid	15	75
Spring	Membrane B	Microfiltration w/acid	15	75
Autumn	Membrane A	Conventional filtration w/acid	15	75
Autumn	Membrane B	Conventional filtration w/acid	15	75
Autumn	Membrane A	Microfiltration w/acid	15	75
Autumn	Membrane B	Microfiltration w/acid	15	75

Table 10-6 Example Of An Experimental Design Summary For A SEBST Study

Season	Membrane	Pretreatment	Water Flux, gfd	Recovery, %
Spring/Summer	Membrane A	Microfiltration w/acid	15	75
Spring/Summer	Membrane A	Microfiltration w/acid	15	90
Autumn/Winter	Membrane A	Microfiltration w/acid	15	75
Autumn/Winter	Membrane A	Microfiltration w/acid	15	90

Table 10-7 Example Of An Experimental Design Summary For A Pilot Membrane Study

Season	Pretreatment	EBCT, min
Spring/Summer	Conventional filtration	10 & 20
Spring/Summer	Enhanced coagulation	10 & 20
Autumn/Winter	Conventional filtration	10 & 20
Autumn/Winter	Enhanced coagulation	10 & 20

Table 10-8 Example Of An Experimental Design Summary For A RSSCT Study

Season	Pretreatment	EBCT, min
Spring	Conventional filtration	10 & 20
Summer	Conventional filtration	10 & 20
Autumn	Conventional filtration	10 & 20
Winter	Conventional filtration	10 & 20

Table 10-9 Example Of An Experimental Design Summary For A Pilot GAC Study

The Materials And Methods Section should include a list of all of the analytical methods used during the treatment study, as well as the minimum reporting level (MRL) for each analyte, as shown in Table 10-10. The ICR specifies that all analyses performed during the treatment studies be conducted using the methods and QA/QC procedures described in the *DBP/ICR Analytical Methods Manual*, and no deviations from these requirements are permitted with the following exception. It is acceptable to use MRLs lower than those specified in the DBP Manual if the following criteria are met: the MRL must be equal to or greater than twice the minimum detection level, and the lab must meet the QC acceptance criteria for the MRL concentration listed in the *DBP/ICR Analytical Methods Manual* at the lower MRL concentration (e.g., if a laboratory reports an MRL of 0.2 mg/L for TOC, then the blank must be $<$ 0.1 mg/L, the low-level calibration verification standard concentration must be 0.2 mg/L, the precision at 0.2 mg/L must be $\leq$ 20% RPD, etc.).

If more than one method or MRL is used for a single analyte or analyte group during the treatment study (e.g., THMs and HAAs in Table 10-10), the different methods and/or MRLs must be reported in the tabular summary.

Analyte	**Method**	**Minimum Reporting Level**
Alkalinity	SM 2320 B	5 mg/L $CaCO_3$
Ammonia	SM 4500-NH_3 D	0.10 mg/L NH_3-N
Bromide	EPA 300.0	10 µg/L
Calcium Hardness	SM 3500-Ca D	5 mg/L $CaCO_3$
Chlorine Residual	SM 4500-Cl D	0.2 mg/L
BCAA, DBAA, DCAA, MBAA, MCAA, TCAA	EPA 552.1	1.0 µg/L for each analyte
BCAA, DBAA, DCAA, MBAA, MCAA, TCAA, BDCAA, DBCAA, TBAA	EPA 552.2	0.5 µg/L for each analyte
pH	SM 4500-H^+	Not Applicable
TDS	SM 2510 B (TDS meter)	5.0 mg/L
Temperature	SM 2550 B	Not Applicable
CHCl3, BDCM, DBCM, CHBr3	EPA 551	1.0 µg/L for each analyte
CHCl3, BDCM, DBCM, CHBr3	EPA 551.1	0.5 µg/L for each analyte
Total Hardness	SM 2340 B	5 mg/L $CaCO_3$
TOC	SM 5310 C	0.20 mg/L
TOX	SM 5320 B	10 µg/L
Turbidity	SM 2130 B	0.05 ntu
UV_{254}	SM 5910	0.003 cm^{-1}

Table 10-10 Example Summary Of Analytical Methods And MRLs Used During A Study

The Materials And Methods Section must include a list of the laboratories involved in the treatment study and the analyses that each laboratory performed. Table 10-11 presents an example summary of laboratories involved a study, including the analyses performed by each laboratory and the period over which these analyses were conducted. In general, it is preferable to use the same method and laboratory for a specific analysis over the course of the study; however, there may be cases in which this is not possible. In the example shown in Table 10-11 the utility's own water quality laboratory performed all of the general water quality analyses and the UV_{254} measurements. Commercial Lab B performed all of the TOC and TOX analyses and the last nine months of THM4 and HAA9 analyses; while Commercial Lab C performed all of the bromide analyses and the first three months of THM4 and HAA6 analyses. Notice that Commercial Lab B analyzed all nine HAAs, while Commercial Lab C only analyzed six HAAs. Also, these two commercial laboratories used different methods and MRLs for THMs and HAAs as shown in Tables 10-10 and 10-11.

Laboratory	Dates of Service	Analyses Performed
Utility Lab A	4/30/98 - 3/30/99	Alkalinity, Ammonia, Calcium hardness, Chlorine residual, pH, TDS, Temperature, Total Hardness, Turbidity, UV_{254}
Commercial Lab B	4/30/98 - 3/30/99	TOC (SM 3510 C), TOX (SM 5320 B)
Commercial Lab B	7/30/98 - 3/30/99	THM4 (EPA 551.1), MRL = 0.5 µg/L per analyte HAA9 (EPA 552.2), MRL = 0.5 µg/L per analyte
Commercial Lab C	4/30/98 - 3/30/99	Bromide (EPA 300.0)
Commercial Lab C	4/30/98 - 7/21/98	THM4 (EPA 551), MRL = 1.0 µg/L per analyte HAA6 (EPA 552.1), MRL = 1.0 µg/L per analyte

Table 10-11 Example Summary Of Laboratories Conducting Analyses During A Study

In addition to the table summarizing the laboratories involved in conducting the analytical work in support of the treatment study, the following information must be provided for each laboratory: the mailing address; the ICR lab ID number (if applicable); and the name, phone number and fax number of a contact person at the lab.

10.6 Section IV: Results And Discussion

The purpose of the Results And Discussion Section is **not** to report the detailed data included in the *Data Collection Spreadsheets*, but rather to provide information that is critical to the interpretation of the results reported in the spreadsheets and to succinctly report the key findings of the study, especially those findings that may not be obvious to an individual evaluating only the raw data.

Section 10.6 is divided into three subsections. Subsection 10.6.1 describes key data elements, common to both GAC and membrane studies, that should be included in the Results And Discussion Section. Subsection 10.6.2 describes approaches that can be used to summarize results from GAC treatment studies; while Subsection 10.6.3 describes the analysis of results from membrane treatment studies.

10.6.1 General Data Elements

The most important information to be captured in the Results And Discussion Section includes study observations that cannot be reported in the spreadsheets, as well as factors that should be considered during the interpretation of the data. A few examples of study observations or factors are listed here:

- During a pilot-scale membrane study, an acid feed pump failed for a three day period (4/1/98 to 4/4/98) resulting in calcium carbonate scale formation on the membrane. The membrane was cleaned with sulfuric acid on 4/4/98 resulting in complete recovery of the lost flux.
- During a single element membrane study, the membrane was cleaned with a 2% solution of sodium lauryl sulfate for two hours. At the end of the cleaning cycle, the color of the cleaning solution changed from clear to a dark green tint.
- During a pilot-scale GAC run, the pilot column was backwashed after 3216 hours of operation (6/15/98). During backwashing, approximately 5% of the GAC was washed out of the 10 minute contactor, resulting an actual EBCT of 9.5 minutes during the final 842 hours of the run.
- During a pilot-scale GAC study, the sixth set of influent and effluent (20 minute EBCT) samples were collected on 4/22/98 during a rain event. The coagulant dose in the full-scale plant was not properly adjusted, and this resulted in a TOC concentration in the influent to the GAC column that was approximately 2.5 mg/L higher than the running average of the influent TOC concentration prior to the rain event.

Since all of the water quality data are included in the *Data Collection Spreadsheets*, it will not be necessary to include large tabular summaries of the treatment study data in the *Treatment Study Summary Report*; however, a table summarizing the average water quality for the treatment study influent can be useful. Table 10-12 shows an example of the influent water quality to a RSSCT for four seasons.

Quarterly bench-scale tests or yearlong pilot studies are required to evaluate the impact of seasonal variability on process performance. A summary discussion of the impacts of seasonal variations in source water quality on process performance should be included in the Results And Discussion Section. Graphs and tables should be used to demonstrate significant seasonal trends in both influent and effluent water quality.

If seasonal variability is determined to be insignificant, the ICR allows other operating parameters to be investigated in lieu of seasonal investigations. Any operating parameters investigated during the study should be reflected in the experimental design in the Materials

And Methods Section, and the impact of the parameters on process performance should be summarized in the Results And Discussion Section using graphs, tables and minimal text.

Water Quality Parameter	**Spring** **Average (SD)**	**Summer** **Average (SD)**	**Autumn** **Average (SD)**	**Winter** **Average (SD)**
Temperature (°C)	18.0 (2.2)	24.0 (1.8)	14.8 (0.9)	7.6 (0.5)
pH	6.70 (0.21)	7.12 (0.28)	7.02 (0.12)	6.81 (0.30)
Turbidity (ntu)	2.14 (0.22)	1.67 (0.12)	2.24 (0.32)	1.24 (0.14)
Alkalinity (mg/L as $CaCO_3$)	21.3 (1.7)	38.6 (2.5)	25.4 (1.9)	20.4 (1.1)
Calcium Hardness (mg/L $CaCO_3$)	110 (7.1)	163 (6.4)	133 (4.2)	108 (3.1)
Total Hardness (mg/L $CaCO_3$)	124 (7.3)	144 (8.2)	136 (6.5)	119 (4.6)
Bromide (µg/L)	28.6 (4.2)	38.5 (5.6)	33.2 (3.7)	24.4 (3.9)
TOC (mg/L)	4.86 (0.80)	5.74 (0.94)	5.04 (0.75)	4.54 (0.54)
UV_{254} (cm^{-1})	0.252 (0.072)	0.304 (0.070)	0.288 (0.051)	0.215 (0.032)
SDS-THM4 (µg/L)	157 (8.6)	195 (12.4)	181 (9.6)	149 (7.1)
SDS-HAA5 (µg/L)	78.3 (4.2)	110.3 (3.9)	84.7 (4.8)	69.4 (4.4)
SDS-HAA6 (µg/L)	85.6 (5.4)	126 (5.8)	109 (6.1)	75.1 (3.8)
SDS-TOX (µg Cl^- /L)	341 (13.6)	392 (22.9)	378 (18.7)	319 (12.9)
SDS-Chlorine Demand (mg/L)	9.6 (1.3)	11.7 (1.0)	11.0 (0.9)	9.1 (0.7)

Table 10-12 Example Tabular Summary Of The Average Pretreated Feed Water Quality During Four Seasons Of A RSSCT Study (*SD = Standard Deviation*)

EPA will use the results of the treatment studies, along with site-specific cost factors reported by the PWS, to estimate both capital and O&M costs for incorporating the advanced treatment process into the existing plant. EPA's approach will standardize the assumptions and models used in the cost analysis but will be unable to incorporate certain site-specific factors. If a PWS conducts it's own cost analysis for the advanced treatment process, EPA requests that the results, assumptions and approach used in the cost analysis be submitted as part of the *Treatment Study Summary Report*. This will allow EPA to compare the results of the on-site cost analysis performed by the PWS to the results of the cost analysis performed by EPA.

10.6.2 Data Elements Specific To GAC Reports

Since GAC is an unsteady-state process, the effluent water quality will vary as a function of operating time. Additionally, for pilot-scale studies, the feed water quality may vary temporally. One way to present this variable water quality data is to plot the feed and effluent concentrations as a function of operating time; these plots are referred to as *breakthrough curves*. Breakthrough curves can also be constructed by plotting concentration as a function of bed volume, which is calculated by dividing the operating time by the empty bed contact time. The water quality parameters for which breakthrough curves are useful include: SDS-THM4 (as well as individual SDS-THM species), SDS-HAA6 (as well as SDS-HAA5 and individual SDS-HAA species), SDS-TOX, TOC, and UV_{254}. Figure 10-5 shows an example of a TOC breakthrough curve along with the feed TOC concentration plotted as a function of time.

From the analysis of breakthrough curves for SDS-THM4 and SDS-HAA5, it is possible to determine the run time (or number of bed volumes) at which the Stage 1 DBP MCLs, proposed Stage 2 DBP MCLs, or other levels of SDS-DBPs are reached. The example in Table 10-13 shows the times at which various DBP precursor breakthrough criteria (i.e., the Stage 1 and proposed Stage 2 MCLs with a 10% factor of safety) were achieved and the corresponding concentrations of other water quality parameters. The time to reach the controlling breakthrough criteria for a given regulatory scenario will determine the required reactivation frequency and thus the cost for the GAC process.

Break-through Criterion	**Value of Listed Parameter When Breakthrough Criterion is Met**						
	Run Time (days)	***Throughput (Bed Vol.)***	***TOC (mg/L***	***SDS-THM4 (µg/L)***	***SDS-HAA5 (µg/L)***	***SDS-HAA6 (µg/L)***	***SDS-TOX (µg Cl^-/L)***
SDS-THM4 = 90 µg/L	95	13680	4.4	90	81	88	200
SDS-THM4 = 72 µg/L	75	10800	3.4	72	61	68	160
SDS-THM4 = 54 µg/L	55	7920	2.4	54	41	48	120
SDS-THM4 = 36 µg/L	35	5040	1.6	36	21	28	80
SDS-HAA5 = 54 µg/L	74	10656	3.5	79	54	63	158
SDS-HAA5 = 27 µg/L	45	6480	1.7	49	27	32	98
SDS-HAA6 = 54 µg/L	66	9504	3.0	71	50	54	142

SDS-HAA6 = 27 μg/L	40	5760	1.5	45	23	27	90

Table 10-13 Example Summary Of Times To Reach Various Breakthrough Criteria And The Water Quality Of The GAC Effluent When Those Criteria Are Met

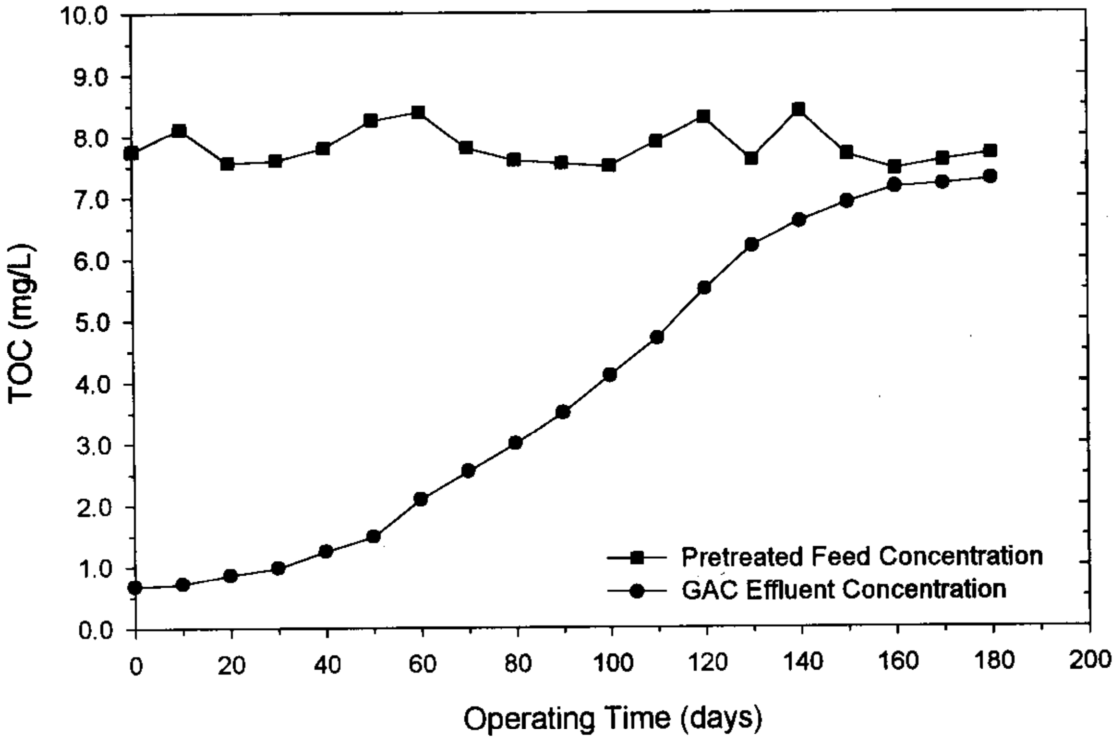

Figure 10-5 Example TOC Breakthrough Curve For A Pilot GAC Run

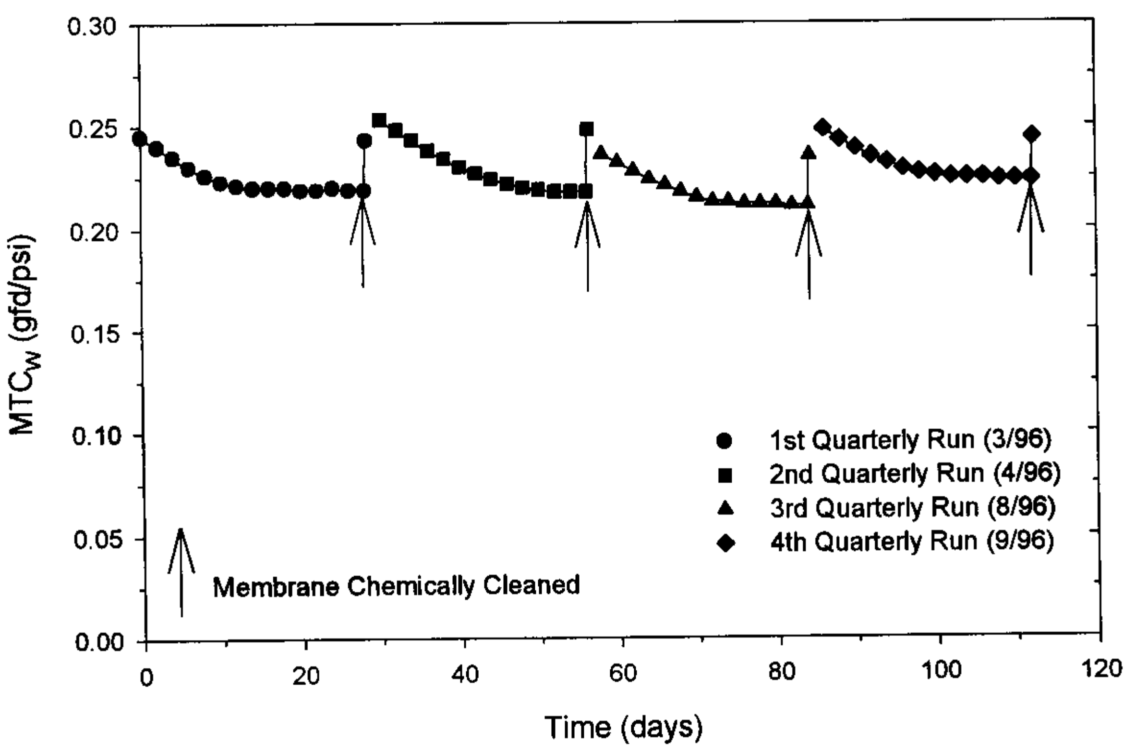

Figure 10-6 Example MTC_W Decline Curve For Four Quarterly Membrane Studies Using The SEBST

EPA will use the results reported in the *Data Collection Spreadsheets* to generate breakthrough curves and will analyze these curves to determine the time, and number of bed volumes, to reach various breakthrough criteria. Breakthrough curves and/or an analysis of these curves generated by the PWS should be submitted as part of the *Treatment Study Summary Report*.

10.6.3 Data Elements Specific To Membrane Reports

Two elements are critical to establish membrane performance: permeate water quality and membrane productivity. With respect to permeate water quality, membrane processes can be approximated as steady-state systems; however, permeate water quality can vary with changes in feed water quality or operating parameters (e.g., recovery). In many cases, the impact of variable feed water quality can be normalized by using the feed rejection or bulk rejection, both of which are calculated by the spreadsheets. Changes in permeate water quality resulting from discrete changes in operating parameters can be summarized by tabulating or plotting permeate concentrations or rejections as a function of the operating parameter under investigation. For example, Table 10-14 shows the effect of recovery on the rejection of various water quality parameters by a nanofiltration membrane.

Water Quality Parameter	**Feed Rejection at Listed Recovery (%)**			
	Recovery = 30%	***Recovery = 50%***	***Recovery = 70%***	***Recovery = 82%***
TDS	78	75	70	62
Ca Hardness	88	86	81	74
Total Hardness	85	83	79	71
Bromide	57	55	51	43
TOC	92	90	87	83
UV_{254}	95	94	91	85
SDS-THM4	95	93	90	85
SDS-HAA5	96	95	93	90
SDS-HAA6	95	93	91	84
SDS-TOX	92	89	87	81

Figure 10-14 Example Of A Tabular Summary Of The Effect Of Recovery On Feed Rejection For A RBSMT Study

Due to the high rejection capabilities of many nanofiltration membranes, permeate water quality can be superior to many MCLs or treatment objectives. This may allow feed water to be blended with permeate water, reducing the membrane area or energy requirements for the plant, thus lowering the cost of the membrane facility. The *Data Collection Spreadsheets* for all types of membrane studies contain cells that calculate the permeate to total flow ratio (i.e., the blend ratio) to achieve the Stage 1 and proposed Stage 2 DBP MCLs with a 10% factor of safety. Assuming that feed/permeate blending is a feasible option, the blend ratios to achieve various treatment objectives can be summarized in a tabular format for use in a cost analysis. The example in Table 10-15 shows the minimum blend ratio that can be used to achieve the specified treatment objective and the resulting water quality at these blend ratios.

Controlling Treatment Objective	**Value of Listed Parameter at Blend Ratio to Achieve Controlling Treatment Objective**					
	Permeate: Total Flow Blend Ratio	***TOC (mg/L)***	***SDS-THM4 (µg/L)***	***SDS-HAA5 (µg/L)***	***SDS-HAA6 (µg/L)***	***SDS-TOX (µg Cl⁻/L)***
SDS-THM4 = 72 µg/L (Recovery = 30%)	0.42	2.8	72	53	58	186
SDS-THM4 = 36 µg/L (Recovery = 30%)	0.84	1.1	36	23	26	83
SDS-THM4 = 72 µg/L (Recovery = 50%)	0.43	2.8	72	53	58	184
SDS-THM4 = 36 µg/L (Recovery = 50%)	0.87	1.1	36	22	25	80
SDS-THM4 = 72 µg/L (Recovery = 70%)	0.45	2.8	72	53	58	182
SDS-THM4 = 36 µg/L (Recovery = 70%)	0.90	1.1	36	23	25	76
SDS-THM4 = 72 µg/L (Recovery = 82%)	0.55	2.5	72	50	55	164
SDS-THM4 = 36 µg/L (Recovery = 82%)	1.11	NA	NA	NA	NA	NA

Table 10-15 Example Summary Of Blend Ratios To Achieve Various Finished Water Qualities For A Nanofiltration Membrane

EPA will use the water quality results contained in the *Data Collection Spreadsheets* to analyze the rejection characteristics of the membrane(s) investigated during the study as well as the water qualities at different blend ratios. Any analysis of the water quality data or membrane rejection characteristics conducted by the PWS should be submitted as part of the *Treatment Study Summary Report*.

Membrane productivity is assessed in terms of the mass transfer coefficient (MTC_W) and the required cleaning interval. The *Data Collection Spreadsheets* for all types of membrane studies contain cells that calculate the temperature-normalized mass transfer coefficient ($MTC_W(Tavg^{\circ}C)$) for each permeate flow measurement, and these data can be plotted as a function of operating time as demonstrated in Figure 10-6. During the run, it is likely that the membrane will need to be periodically cleaned when a predetermined drop in $MTC_W(Tavg\ ^{\circ}C)$ occurs, and these cleaning events are indicated using arrows in Figure 10-6.

The time rate of MTC_W decline between two sequential cleaning events (or between the start of the run and the first cleaning event) can be used to estimate the required cleaning interval[2]. Table 10-16 summarizes the average cleaning interval, along with other productivity information, for different operating conditions during a membrane study.

Operating Conditions	Average Rate of MTC_W Decline (gfd/psi/day)	Average Cleaning Interval* (days)	Initial MTC_W (gfd/psi)	Final MTC_W (gfd/psi)	MTC_W After Cleaning (gfd/psi)
Wet Season, Low Flux	$-9.77x10^{-4}$	35	0.228	0.194	0.220
Wet Season, High Flux	$-1.21x10^{-3}$	28	0.225	0.191	0.214
Dry Season, Low Flux	$-5.61x10^{-4}$	62	0.232	0.197	0.224
Dry Season, High Flux	$-6.27x10^{-4}$	55	0.230	0.196	0.216

** Cleaning interval is calculated assuming a 15% drop in MTC_W prior to cleaning.*

Table 10-16 Example Summary Of Average Membrane Productivity Observed Under Different Operating Conditions During A Membrane Treatment Study

EPA will use the productivity information contained in the *Data Collection Spreadsheets* to generate MTC_W decline plots and analyze these plots to determine the required cleaning interval under various operating conditions. MTC_W decline plots and/or an analysis of these plots generated by the PWS should be submitted as part of the *Treatment Study Summary Report*.

10.7 Section V: QA/QC Summary

The ICR requires that all analyses performed during a treatment study be conducted according to the QA/QC procedures described in the *DBP/ICR Analytical Methods Manual*. In addition to these requirements, field duplicates must be collected for all analytes monitored during the study at the rate specified in the *ICR Manual for Bench- and Pilot-Scale Treatment Studies*. The results from field duplicates are reported directly in the *Data Collection Spreadsheets*. In addition to the field duplicate results reported in the *Data Collection*

[2] The method for estimating the cleaning interval from the MTC_W decline plot is presented in Part 3 of the *ICR Manual for Bench- and Pilot-Scale Treatment Studies*.

Spreadsheets, the *Treatment Study Summary Report* must contain a QA/QC Summary which must include:

- The results of all laboratory duplicates.
- The results of all laboratory fortified matrix sample analyses.
- The results of any independent QC checks (e.g., PE samples).
- A summary of the calibration procedures for the DBP, bromide and TOC analyses.

> **Note:** Although only a portion of the QC results are to be reported in the *Treatment Study Summary Report*, a complete record of all required QC must be maintained by labs conducting analyses in support of the ICR treatment studies. In the event of a laboratory audit by EPA, any or all of the QC data must be furnished in a clear and organized format upon request.

Table 9.8 of the *DBP/ICR Analytical Methods Manual* lists the requirements for performing laboratory duplicates (note that some methods require field duplicates in lieu of laboratory duplicates). Laboratory duplicates provide an effective means of evaluating laboratory precision; thus, the QA/QC Summary must include the following information for each duplicate analysis performed during a treatment study: the results from both the primary and duplicate analyses; the average concentration and relative percent difference for the primary and duplicate analyses; the sample collection date and time; and the sample ID as listed in the *Data Collection Spreadsheets*. When reporting the results from samples that were analyzed in duplicate, only the average concentration is entered in the *Data Collection Spreadsheets*.

> **Note:** There is no requirement to analyze laboratory duplicates for water quality parameters such as pH, alkalinity, hardness, etc.; however, analyzing laboratory duplicates for these water quality parameters at a rate of 5% will provide useful information on the precision of these measurements. Any analysis of laboratory duplicates for these water quality parameters should be reported in the QA/QC Summary.

Tables 9.9 and 9.10 of the *DBP/ICR Analytical Methods Manual* list the required frequencies and concentrations for performing laboratory fortified matrix sample analyses. The following information must be reported in the QA/QC Summary for all fortified matrix samples analyzed during the treatment study: the concentration of the unfortified sample, the concentration of the laboratory fortified matrix sample, the fortifying concentration, and the percent recovery of the fortifying concentration[3].

Although not a requirement, it is anticipated that many ICR approved laboratories will be conducting analyses in support of the ICR treatment studies. ICR approved labs will be required to participate in PE studies to maintain ICR approval status. Additionally, both ICR and non-ICR laboratories may be involved in other PE studies such as the Water Supply (WS) or Water Pollution (WP) Series PE Studies. If a lab is involved in a PE study for DBPs,

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[3] The percent recovery of the fortifying concentration is defined as the difference between the concentration of the fortified sample and the unfortified sample, divided by the fortifying concentration. The result is multiplied by 100%.

bromide, TOC, UV_{254} or any of the water quality parameters during the ICR treatment studies, the results of the PE study should be submitted as part of the QA/QC Summary. The information that should be reported for all relevant PE samples analyzed during the treatment studies includes: the organization coordinating the PE study (e.g., U.S. EPA), the measured concentration of the PE sample, the true value of the PE sample and the percentage of the measured value relative to the true value.

Laboratories conducting analyses for the ICR treatment studies must use approved methods and must use calibration procedures consistent with these approved methods. The *DBP/ICR Analytical Methods Manual* also requires that the calibration be verified at the frequency shown in Table 9.1, and the acceptance criteria for low-, mid-, and high-level calibration checks are listed in Tables 9.2, 9.3 and 9.4, respectively. (Note, if a lab uses a MRL concentration lower than the MRL specified in the DBP Manual, then the low-level calibration check must be performed using a standard at the lower MRL concentration.) Failure to meet the frequency or calibration verification acceptance criteria listed in the *DBP/ICR Analytical Methods Manual* constitutes a QC failure, and the results from sample analyses associated with this failure must not be reported with the treatment study results.

The QA/QC Summary should reference, and if necessary briefly describe, the calibration procedure used for each method along with the frequency and procedure used to verify the calibration. The individual results for each calibration verification standard should **not** be reported in the QA/QC Summary; however, these results must be documented in the laboratory QC record.

11.0 Submitting The *Final Treatment Study Report*

The *Final Treatment Study Report* consists of data reported in the *ICR Treatment Study Data Collection Spreadsheets* described in this document, and the hard-copy *Treatment Study Summary Report* described in Section 10.0 of this document. This final report is due in its entirety no later than **July 14, 1999**, and must include the following elements:

- A hard-copy of the *Treatment Study Summary Report*.
- One or more 3.5 inch diskettes containing the *Treatment Study Summary Report* computer files.
- Hard-copies of all *Data Collection Spreadsheet* fields containing treatment study data.
- One or more 3.5 inch diskettes containing the appropriate *Data Collection Spreadsheets* in which the treatment study data has been saved.

The *Treatment Study Summary Report* computer files are being requested so that key data elements can be extracted for use in a comprehensive summary of the ICR treatment study results. The *preferred* format for these computer files is described here. Text from the summary report should be provided in either Microsoft Word or Word Perfect. When possible, tables should be incorporated into the text (i.e., create either Word or Word Perfect tables), but it is also acceptable to include tables as Microsoft Excel files. Graphs should be included as Microsoft Excel or Sigma Plot files. Drawings or other graphics can be provided in Microsoft Word, Word Perfect, Freelance, Harvard Graphics or Microsoft Power Point.

The spreadsheets must be submitted in Excel 5.0 for Windows format. In order to help EPA track the *Data Collection Spreadsheets*, the spreadsheet file should be named using the following format: **ICR**, followed by the **three or four digit plant ICR#**, followed by the **.xls** extension (e.g., *ICR1234.xls*). In order to save the spreadsheet files to a standard 1.44 MB high density diskette, it may be necessary to reduce the file size. This can be accomplished in one of two ways. One approach is to delete worksheets in the *Data Collection Spreadsheet* which do not contain treatment study data (e.g., example or empty field-sets). If this does not reduce the file size sufficiently to allow it to be saved to a 1.44 MB diskette, then the file will need to be compressed. This can be accomplished by "zipping" the file(s) using the PKZIP software included with the *Data Collection Spreadsheets*. The procedure for compressing a file is described in Section 3.5 of this document. The compressed file name should be identical the to Excel file name, except that the **.zip** extension should be used instead of **.xls**.

Note: The PKZIP file included with the *ICR Treatment Study Data Collection Spreadsheets* is only licensed for use during submission of results from the ICR Treatment Studies to EPA. Any other use of this licensed copy of PKZIP is prohibited.

If multiple studies were conducted by the PWS, a *Final Treatment Study Report* must be submitted for each study and shall contain all of the elements listed above. Copies of all of this information, including hard-copies and spreadsheet files, must be saved by the PWS for at least three years after the final report has been submitted to EPA.

The *Final Treatment Study Report* shall be submitted to:

U.S. EPA - OGWDW
Technical Support Center, MS 140
ICR Treatment Studies Coordinator
26 West Martin Luther King Drive
Cincinnati, Ohio 45268

Questions regarding data submission should be directed to the Safe Drinking Water Hotline at 1-800-426-4791 or the ICR Treatment Studies Coordinator at 513-569-7131.