REMSTAT 2002

Remining Statistical Analysis Tool

Baseline Determination and Monitoring for Pre-existing Discharges

User's Manual

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Prepared for

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Disclaimer

REMSTAT 2002 is intended as a tool to assist coal mining companies in compliance with the effluent limitations and standards promulgated for the Coal Remining Subcategory of the Coal Mining Point Source Category (40 CFR 434, Subpart G). REMSTAT 2002 is not intended, nor can it be relied upon, to create any rights enforceable by any party in litigation. A permitting authority may decide to follow the guidance or results provided by REMSTAT and this User's Manual, based on its analysis of the specific facts presented.

REMSTAT 2002 User's Manual

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1.0 INTRODUCTION

On January 23, 2002 (67 FR 3370), EPA promulgated guidelines for development and monitoring of effluent limits in pre-existing discharges at coal remining operations. REMSTAT 2002 provides a tool for mine operators and permit writers to establish effluent limitations for pre-existing discharges and/or hydrologic units and then to monitor for exceedance during and after completion of the mining operation until final bond release. Examples of the statistical procedures used in REMSTAT 2002 are presented in Appendix A.

REMSTAT 2002 comes packaged on the installation CD-ROM so that it will automatically install itself when the setup program is run. Follow the steps below to install REMSTAT 2002 on your computer.

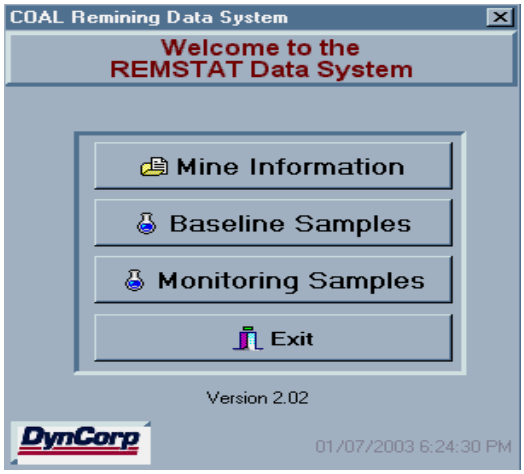
- Insert the REMSTAT 2002 CD-ROM in your CD-ROM drive.
- Select the Windows "Start" button.
- Select "Run..."
- Either browse to your CD-ROM drive and select setup.exe or type in the drive letter of your CD-ROM followed by setup.exe, (e.g., D:\setup.exe) then click on "OK."
- Follow instructions that appear on your screen.

REMSTAT is divided into three parts that must be performed sequentially. Each part uses information entered or calculated from the previous part. The three parts are:

a. Mine/Discharge Identification (Mine Information)
b. Baseline Data Entry and Statistics Calculation (Baseline Samples)
c. Monitoring Data Entry and Statistics Calculation (Monitoring Samples)

The current version of REMSTAT has the capability to evaluate data from multiple mines. The opening screen of REMSTAT is shown in Figure 1.

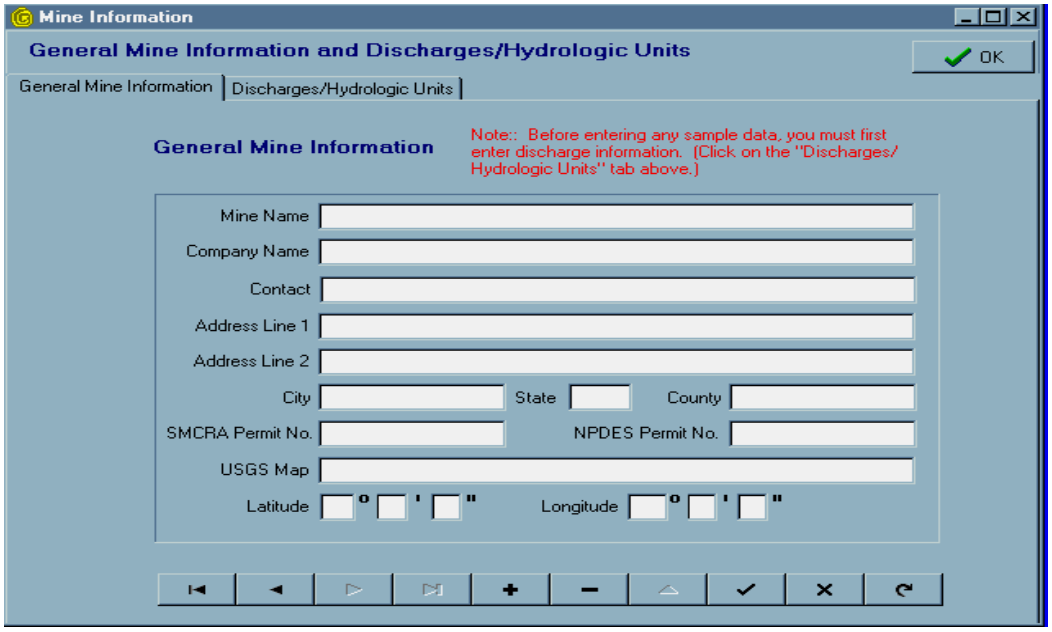
Figure 1. Opening Screen



2.0 MINE/DISCHARGE INFORMATION

Before data entry can begin, the user must enter mine site information and define all the pre-existing discharges and/or hydrologic units containing pre-existing discharges at the site. The Mine Information Screen (Figure 2) is accessed by selecting the "Mine Information" button on the opening screen.

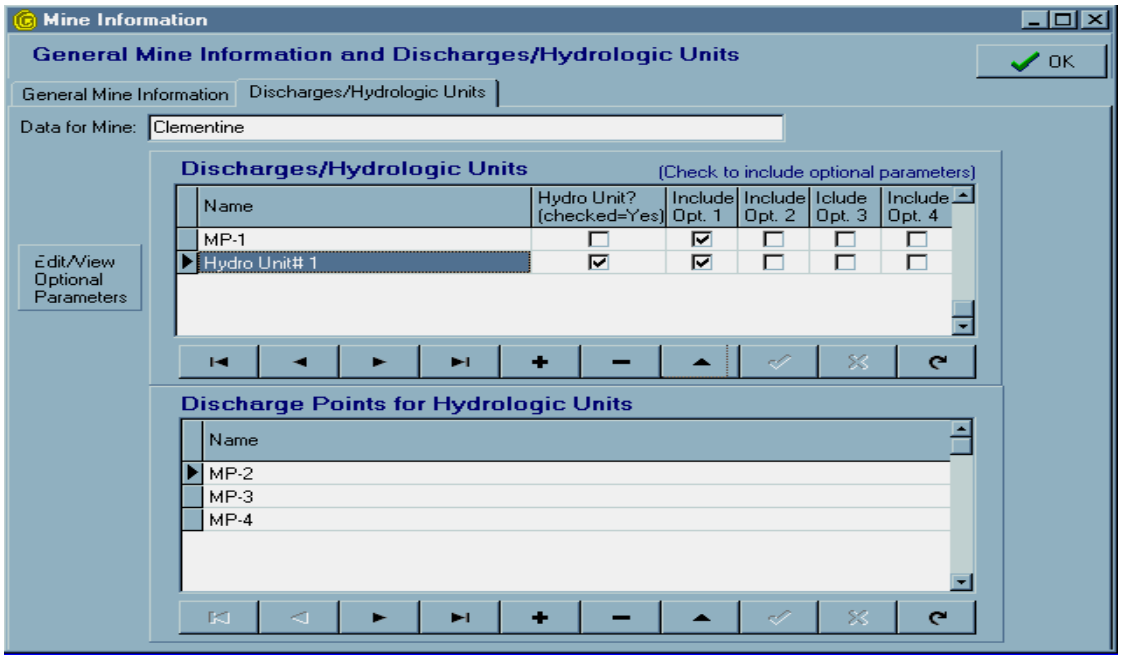
Figure 2. Mine Information Screen



If you are using REMSTAT for the first time, the General Mine Information Screen will be blank. Once information has been entered for a given site, a new mine can be added to the system by selecting the "+" navigation button on the bottom of the screen. When this button is selected, a new blank Mine Information Screen will appear. Each mine and information related to that mine will appear on all screens until an alternative mine is selected.

After entering the mine site information, the user defines all discharges and/or hydrologic units. To begin, select the "Discharge/Hydrologic Units" tab near the top of the screen. The Discharge/Hydrologic Unit Definition Screen (Figure 3) will open. In this screen, single pre-existing discharges and pre-existing discharges that make up hydrologic units are defined. Typically, a single sample point is used to characterize a pre-existing discharge and several discharges are used to characterize a hydrologic unit.

Figure 3. Mine Information - Discharge/Hydrologic Units Screen

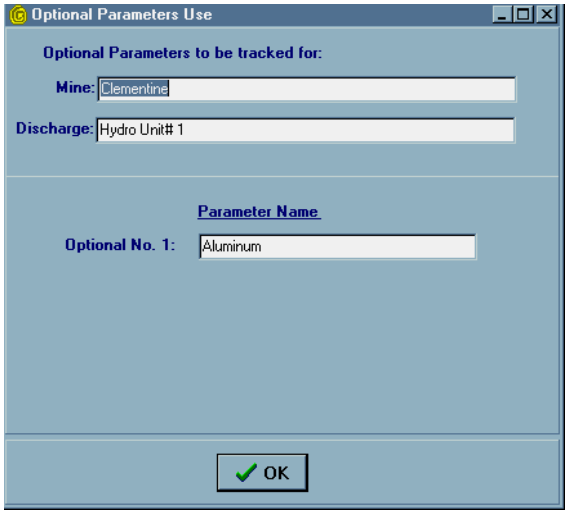


Single pre-existing discharges must be listed in the top half of the screen. Hydrologic units also must be listed in the top half of the screen (e.g., Hydro Unit# 1) and the "Hydro Unit?" box checked. When this box is checked, a second box ("Discharge Points for Hydrologic Units") opens in the bottom of the screen to allow you to list the discharges that make up the hydrologic unit. **Do not list discharges that belong to a hydrologic unit in the top half of the screen.** In Figure 3, MP-2, MP-3, and MP-4 are all discharges within the hydrologic unit named "Hydro Unit# 1." MP-1 is a single discharge.

When calculating baseline and monitoring statistics for hydrologic units, REMSTAT aggregates data for all discharges belonging to a hydrologic unit by adding the loads from all discharges within each hydrologic unit. REMSTAT then calculates the statistics as if the hydrologic unit were a single discharge.

Optional Parameters: In addition to providing columns to track iron, manganese, and net acidity, REMSTAT allows the user to track up to four optional parameters for each discharge. Optional parameters can be selected and defined by checking "Include Option" boxes to the right of each discharge or hydrologic unit. Each additional optional parameter can be defined by selecting the "Edit/New Optional Parameters" button. If the "Edit/New Optional Parameters" button is selected, a screen like the one shown in Figure 4 opens.

Figure 4. Optional Parameters Use Screen



3.0 BASELINE DATA ENTRY

Note: It is important that the discharge/hydrologic unit information be correct before proceeding to the Baseline Data Entry phase. Discharge data may be lost if edits are made to discharge or monitoring point information after baseline data entry has started.

To begin baseline data entry, the user selects "Baseline Samples" in the opening screen (Figure 1) and then selects "Data Entry" in the Baseline Samples Menu. The Baseline Samples Menu and Data Entry Screens are shown as Figures 5 and 6, respectively.

Figure 5. Baseline Samples Menu

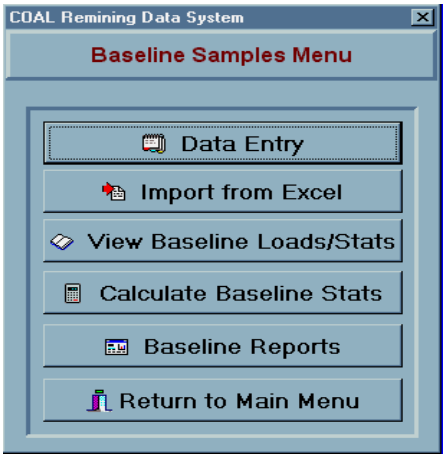
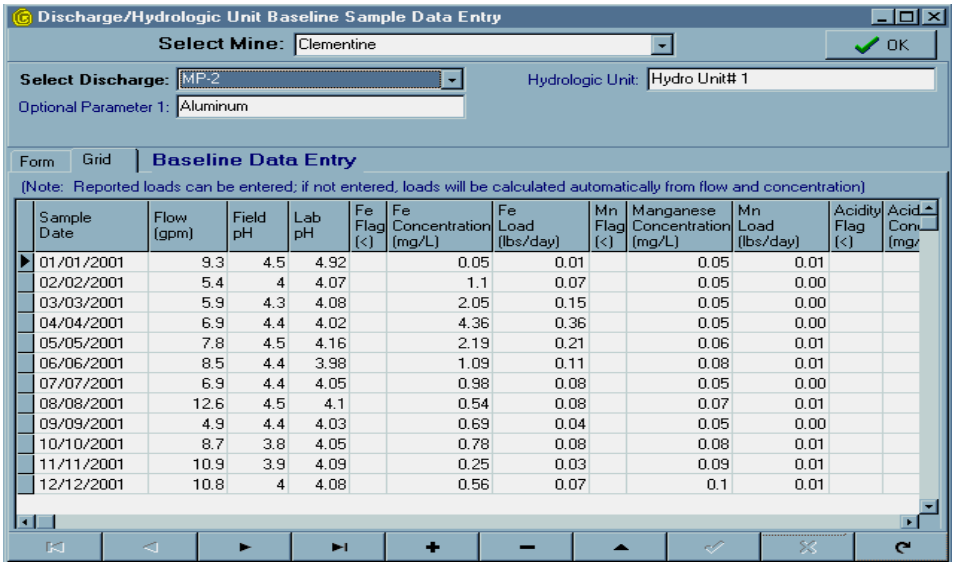


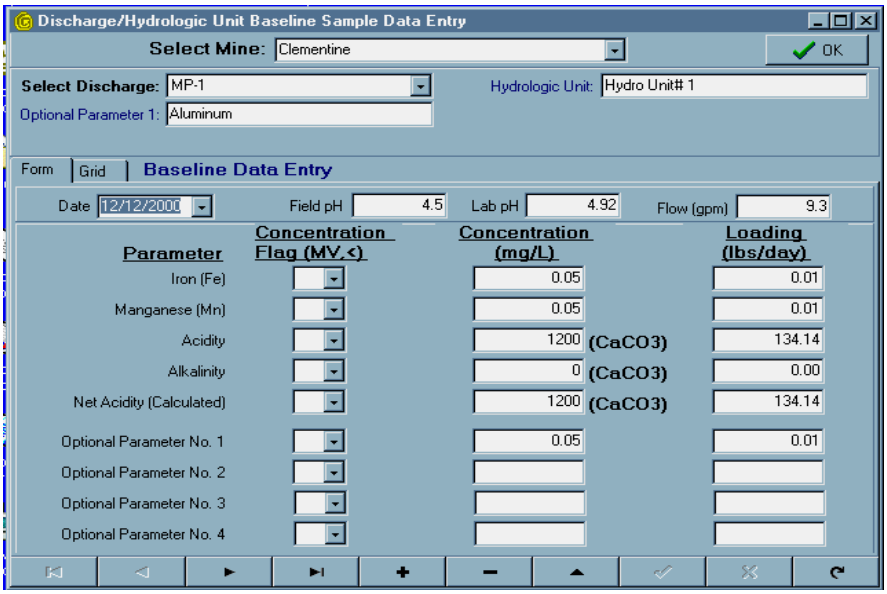
Figure 6. Baseline Data Entry Screen



Sample Date	Flow (gpm)	Field pH	Lab pH	Fe Flag (<)	Fe Concentration (mg/L)	Fe Load (lbs/day)	Mn Flag (<)	Manganese Concentration (mg/L)	Mn Load (lbs/day)	Acidity Flag (<)	Acid Con (mg/
01/01/2001	9.3	4.5	4.92		0.05	0.01		0.05	0.01		
02/02/2001	5.4	4	4.07		1.1	0.07		0.05	0.00		
03/03/2001	5.9	4.3	4.08		2.05	0.15		0.05	0.00		
04/04/2001	6.9	4.4	4.02		4.36	0.36		0.05	0.00		
05/05/2001	7.8	4.5	4.16		2.19	0.21		0.06	0.01		
06/06/2001	8.5	4.4	3.98		1.09	0.11		0.08	0.01		
07/07/2001	6.9	4.4	4.05		0.98	0.08		0.05	0.00		
08/08/2001	12.6	4.5	4.1		0.54	0.08		0.07	0.01		
09/09/2001	4.9	4.4	4.03		0.69	0.04		0.05	0.00		
10/10/2001	8.7	3.8	4.05		0.78	0.08		0.08	0.01		
11/11/2001	10.9	3.9	4.09		0.25	0.03		0.09	0.01		
12/12/2001	10.8	4	4.08		0.56	0.07		0.1	0.01		

Data entry can begin as soon as the user selects a mine and discharge from the drop down lists at the top of the Data Entry form. Data can be entered in the grid (or spreadsheet) view as shown in Figure 6 or in a form view (for a single sample) as shown in Figure 7. In the grid view, the user can adjust the grid to ease data entry by dragging and grouping the columns. The user can alternate between the two screens by selecting either the "Form" or "Grid" tabs near the top of the Baseline Data Entry Screen.

Figure 7. Form View of Baseline Data Entry Screen



Parameter	Concentration Flag (MV,<)	Concentration (mg/L)		Loading (lbs/day)
Iron (Fe)		0.05		0.01
Manganese (Mn)		0.05		0.01
Acidity		1200	(CaCO3)	134.14
Alkalinity		0	(CaCO3)	0.00
Net Acidity (Calculated)		1200	(CaCO3)	134.14
Optional Parameter No. 1		0.05		0.01
Optional Parameter No. 2				
Optional Parameter No. 3				
Optional Parameter No. 4				

3.1 Optional Parameters

The current version of REMSTAT allows data entry for up to twelve parameters. Eight of the twelve parameters are fixed. In addition, four optional parameters can be defined by the user. Optional parameters may be selected and defined per instructions in Section 2 (Figure 4). The twelve parameters in REMSTAT are:

- Flow (gpm)
- Field pH (Standard Units)
- Lab pH (Standard Units)
- Alkalinity (mg/L as $CaCO_3$)
- Acidity (mg/L as $CaCO_3$)
- Net Acidity (mg/L as $CaCO_3$) [Calculated or data entry field]
- Total Iron (Fe)
- Total Manganese (Mn)
- Optional Parameter No. 1 (mg/L)
- Optional Parameter No. 2 (mg/L)
- Optional Parameter No. 3 (mg/L)
- Optional Parameter No. 4 (mg/L)

The user may either enter net acidity results or both alkalinity and acidity data. If acidity and alkalinity data are entered by the user, net acidity is calculated automatically and stored as the result of acidity minus alkalinity. This calculated value will over-write any value for net acidity entered by the user. REMSTAT will accept negative acidity or alkalinity values, but will set them to zero before calculating loadings and before calculating net acidity. However, negative net acidity (as the result of acidity minus alkalinity) will not be set to zero. In these cases, the program will generate and use negative net acidity mass loads.

3.2 Data Entry Rules

The following rules must be followed during data entry:

1. All sample dates must be entered with a four-digit year (e.g., 1999, 2000, etc.).

2. Data for each discharge should be entered in chronological order.

3. Flow values are always expressed as gallons per minute (gpm).

4. pH values are entered as standard units. All other parameter values are entered as either concentrations or mass loads. Concentrations are expressed in terms of milligrams per liter (mg/L). Mass loads are expressed in terms of pounds per day (lbs/day).

5. When a concentration measurement is “below-detect,” enter “<“ in the flag field and enter the analytical minimum level (ML) value in the corresponding concentration field. The ML should be known to the laboratory and is associated with EPA-approved analytical methods.

For example, the MLs for Iron and Manganese reported in EPA Methods 236.1 and 243.1 are 0.03 mg/L and 0.01 mg/L, respectively. [Note: If only the Method Detection Limit (MDL) or Instrument Detection Limit (IDL) value is known, multiply the MDL or IDL by 3.18 and round the result to the number nearest to (1, 2, or 5) x 10^n, where n is an integer. For example, 0.0749 would be rounded to 0.05; 0.0753 would be rounded to 0.10.]

6. The flag field is designed to hold the following non-numeric information:

   "<" Less than a minimum level (**Note: When this flag is used, a minimum level (ML) must be entered as concentration. When "<" is entered, REMSTAT will use ½ the ML to calculate mass load.**)

   "MV" Missing value (**Note: Discharge and hydrologic unit data containing "MV" will not be used for baseline determination and monitoring.**)

7. In order for a sample to be included in statistical calculations, pollutant load information must be available. For load information to be available, at least one of the following two conditions of data entry must be met: Either load is entered **OR** both flow and concentration are entered (REMSTAT will calculate load).

8. If a zero flow is entered (e.g., discharge is dry, stagnant, or frozen), either concentration or loading also must be entered for all the parameters of interest before results for those parameters can be included in the statistical calculations. If a sample of standing water was collected and analyzed, the flow is reported as zero and concentration results entered. In this case, REMSTAT will calculate zero loadings for each parameter for that particular day when flow is reported as zero.

9. In order for a hydrologic unit to be complete, all discharges within the hydrologic unit must have corresponding sample dates.

3.3 Importing Baseline Data From Excel Spreadsheets

REMSTAT users also may import data for baseline samples from existing Excel files. The import process is a two-step process which involves copying existing Excel data to an import template and then importing template data into the baseline database.

It is important to note that the mine and discharge information must be in REMSTAT (Mine Information) before data can be imported. The steps to be followed during the import process are as follows:

1. Upon installation, REMSTAT places a copy of the template called "ImportTemplate.xls" in the REMSTAT program directory (C:\Program Files\REMSTAT). The first step of the import process is for the user to copy the existing Excel data into the template. The template forces the user to put the parameter data in the specific, defined columns beginning on row 20.

2. To begin the import process from within REMSTAT, the user selects the "Import from Excel" button on the Baseline Samples Menu (Figure 5). An import form as shown in Figure 8 opens.

3. The user must supply the following four pieces of information before the import process can begin:

   - The appropriate mine must be selected;
   - The appropriate discharge must be selected;
   - The appropriate path to the import template file must be identified; and
   - The appropriate worksheet number must be selected. (Note: REMSTAT includes a default worksheet number of one. If the data to be imported are in the first worksheet of the import template file, the default worksheet number does not have to be changed from one).

4. A few tips to make the import process work smoothly are:

   - Prepare the "Import Template" spreadsheet before starting REMSTAT.

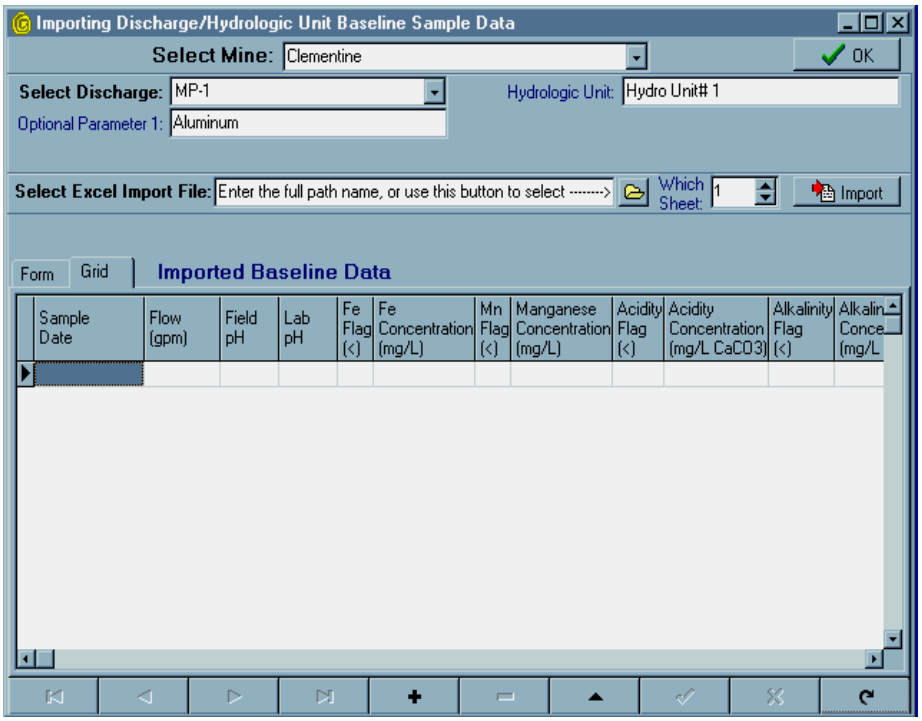
   - A date must be filled in for every row in the import spread sheet. The import process stops when it encounters a blank date.

   - Data can be reported as less than ML values (e.g., <10) in a single cell in the template. REMSTAT will parse the imported information and place the "<" in the flag field and the number in the concentration field.

   - Missing Values ("MV" flags) will need to be added after data are imported. Do not code missing values as zeros. It is essential that true zero data and missing values should not be confused.

5. Once the above information has been provided in the template, selecting the Import button will bring the template data into a temporary file that can be viewed and edited. Once the data are all correct, the user must determine whether the data import is an "Add/Update" or "Replace" by selecting the appropriate option button. Once the appropriate option button has been selected, the user selects the import button and the data are included in the baseline database.

Figure 8. Baseline Import Screen



3.4 Calculation of Mass Load

After the user completes data entry for a discharge and exits the "Data Entry Screen," REMSTAT automatically calculates mass-based equivalents from the concentration and flow data. The following equation is used to convert concentration (mg/L) and flow (gpm) to mass load (lbs/day):

Mass Load (lbs/day) = flow (gpm) x concentration (mg/L) x 0.01202 (conversion factor)

If only mass load information is available, the user can enter it directly into the appropriate lbs/day field. However, if concentration, flow, and mass load information are entered for a parameter, the calculated mass load will replace an entered mass load. The mass load fields are located on the same screen (form view) or to the right of the concentration fields (grid view).

- When a "<" flag is entered for a parameter, a minimum level (ML) must be entered as the concentration. The program assumes the concentration reported for the parameter is an analytical limit and uses one-half this reported value to calculate the mass load for that parameter for that day.

- When an "MV" is entered, REMSTAT cannot calculate loadings, and the corresponding parameter for that discharge on that date will not be included in statistics calculations. Similarly, if an MV is reported for any discharge of a hydrologic unit, the aggregated mass

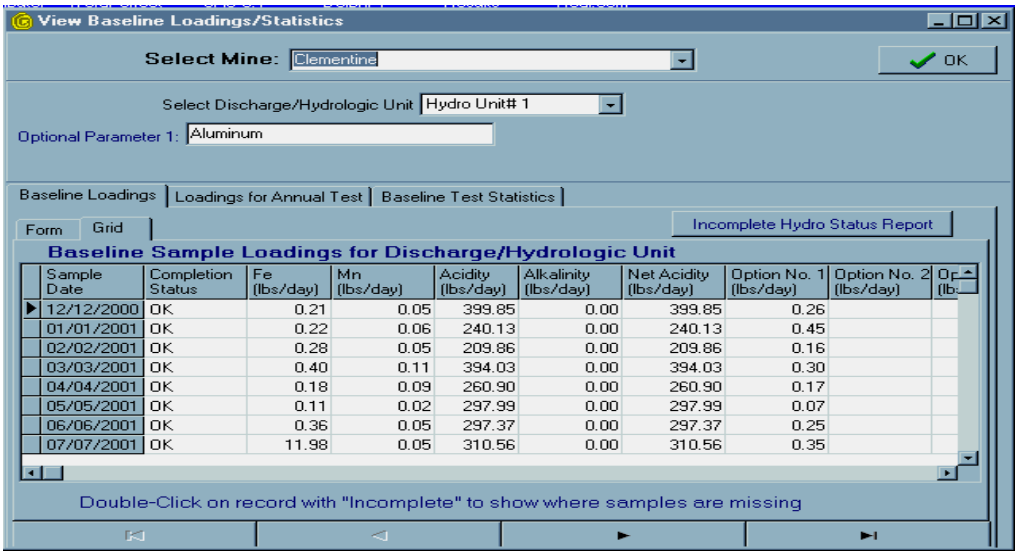
load for that parameter for that day will not be included in statistical calculations performed for that parameter for that sample date.

3.5 Hydrologic Unit Assumptions/Rules

Mass load data (lbs/day) from all discharges within a hydrologic unit are aggregated by parameter and date into a single mass load for the hydrologic unit. This allows the comparison of baseline loading from a single hydrologic unit to loading during monitoring of the same hydrologic unit.

To ensure that the program properly handles hydrologic unit data, samples from all discharges within a hydrologic unit that are collected during a corresponding time period must have the same date (e.g., in order for hydrologic unit data to be aggregated, samples collected from separate discharges within a hydrologic unit over a week-long period, must be assigned the same date). To determine whether appropriate dates have been entered for discharges within a hydrologic unit, the user can select the "View Baseline Loads/Stats" button on the Baseline Menu, select the appropriate Hydrologic Unit, and look under the completion status column (see Figure 9). An "OK" indicates that corresponding sample dates have been entered for all discharges within the hydrologic unit.

Figure 9. Baseline Loading Statistics Screen



Sample Date	Completion Status	Fe (lbs/day)	Mn (lbs/day)	Acidity (lbs/day)	Alkalinity (lbs/day)	Net Acidity (lbs/day)	Option No. 1 (lbs/day)	Option No. 2 (lbs/day)
12/12/2000	OK	0.21	0.05	399.85	0.00	399.85	0.26	
01/01/2001	OK	0.22	0.06	240.13	0.00	240.13	0.45	
02/02/2001	OK	0.28	0.05	209.86	0.00	209.86	0.16	
03/03/2001	OK	0.40	0.11	394.03	0.00	394.03	0.30	
04/04/2001	OK	0.18	0.09	260.90	0.00	260.90	0.17	
05/05/2001	OK	0.11	0.02	297.99	0.00	297.99	0.07	
06/06/2001	OK	0.36	0.05	297.37	0.00	297.37	0.25	
07/07/2001	OK	11.98	0.05	310.56	0.00	310.56	0.35	

It is important to note that the program will not calculate baseline statistics until the "Completion Status" is "OK" for all the dates of a hydrologic unit. As noted previously, the completion status indicator only applies to hydrologic units. The "Incomplete" flag indicates that sample data for one or more of the discharges within the hydrologic unit have not been entered for that date. Selecting the "Incomplete Hydro Status Report" button (upper right) will generate a report of missing discharges for all dates within the hydrologic unit. Double clicking on a row that is

"Incomplete" also will open a window showing the discharge(s) for which a sample for that date is missing.

The hydrologic unit completion status can be changed in one of the following three ways:

1. Note the dates that are indicated as "Incomplete." Go to the data entry screen and check the dates in question for the discharges in question. If a date was omitted or entered in error for one of the discharges, the date should be corrected or sample results entered. This will complete the hydrologic unit for that date.

2. If data are not available for one of the discharges within the hydrologic unit for a given sample date, the user can flag the parameter data as "MV." **It is important to remember that dates containing data that include an "MV" flag will not be aggregated or used in statistical calculations.**

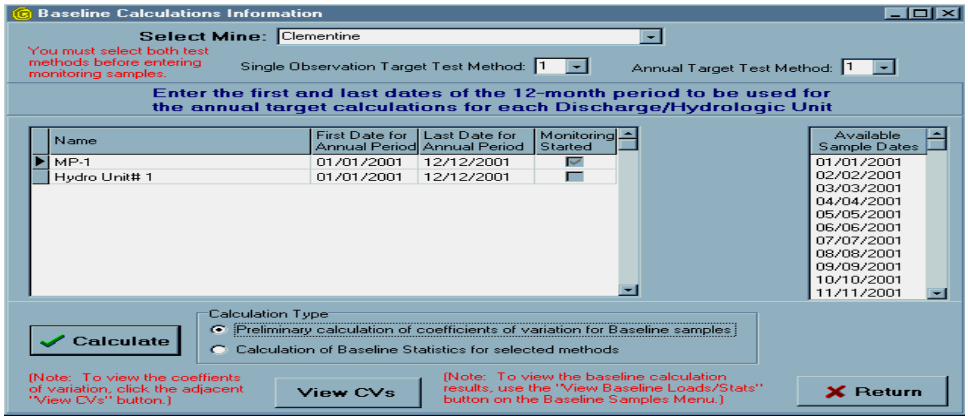
3. The user can delete the records for the dates in question for all the discharges within the hydrologic unit. In this case, all sample information for this date will be omitted from statistical calculations.

3.6 Baseline Calculations -- Choice of Statistical Method

REMSTAT is able to calculate and report the results of baseline loadings and monitoring information using one of two statistical methods (Statistical Method 1 or Statistical Method 2) for the single-observation trigger and annual test comparison. These methods are described using examples in Appendix A to this User's Manual (see also Federal Register, volume 67, page 3408 to 3410, for January 23, 2002).

Once data entry has been completed for all baseline samples, the baseline statistics can be generated. This is accomplished by selecting "Calculate Baseline Stats" in the Baseline Samples Menu (Figure 5). This will open the "Baseline Calculations Information" Screen (Figure 10).

Figure 10. Baseline Calculations Information Screen



This screen is used for all aspects of baseline calculations. Prior to the actual calculations, the user must first select which single observation and annual test method will be used to evaluate samples. EPA's recommendation regarding statistical method selection depends in part on the coefficient of variation of the baseline sample loadings. REMSTAT will calculate these coefficients of variation (See Section 3.7 below) to assist the user in selecting a statistical method.

> ***EPA recommends that the results of Statistical Method 1 be used in most cases.*** The results of Method 2 provide an additional level of protection against false positives and, therefore, are less able to detect an increase above baseline loadings. Therefore, Statistical Method 2 should be considered for use only when the duration of monitoring is expected to be unusually long (5 years or more) or when the variability of baseline loadings was especially high, as indicated by an unusually high coefficient of variation (CV). Specifically, EPA recommends that the results of Statistical Method 2 be used ***only*** when the sample CV of the baseline loadings exceeds 1.25 or when the number of monitoring months per discharge is expected to be substantially greater than 60.

REMSTAT currently allows the user to select the statistical method at the mine site level and does not allow the user to select a statistical method for each parameter within a discharge or hydrologic unit. Therefore, the statistical method selected is applied to all parameters in all discharges/hydrologic units associated with the mine site. If sample CVs or expected monitoring durations indicate that Statistical Method 2 should be used for one or more parameters, there are two possible courses of action:

(1) Create two "mines" with slightly different names, for example "Red Dog - Method 1" and "Red Dog - Method 2" using Statistical Method 1 for one "mine" and Statistical Method 2 for the other. The exact same data would be entered (or imported) for both "mines." Alternatively, the user could enter only that data associated with the parameter(s) for which Method 2 may be appropriate.

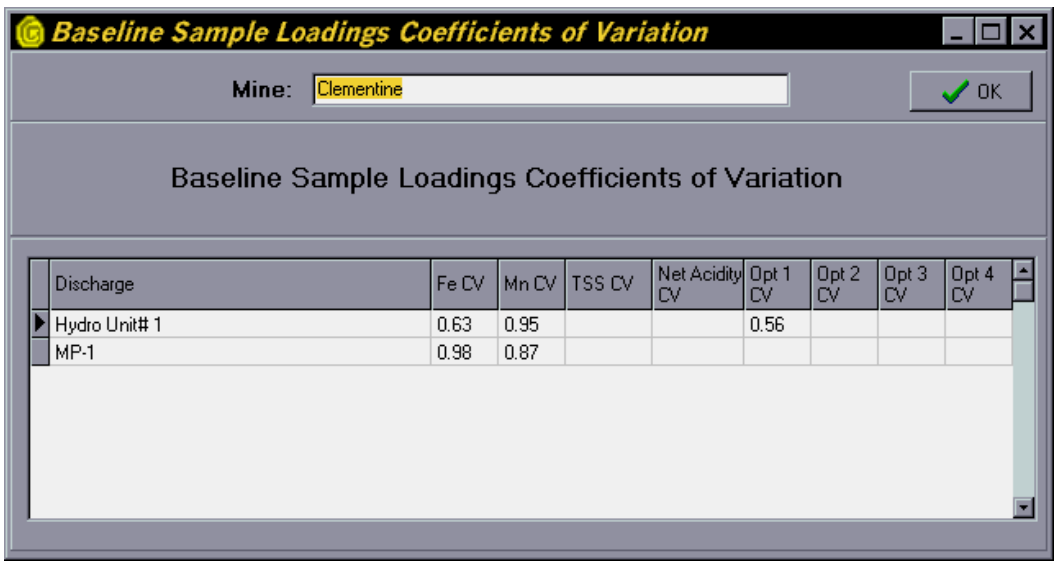
(2) If you are considering selecting Statistical Method 2 for a mine site, first carefully evaluate the need by considering the following: (a) different parameters can be expected to have similar CVs, so substantial differences in sample CVs may be due largely to sampling or data error, (b) Methods 1 and 2 are expected to give similar results if the sample CV of a parameter is not much above 1.25; and (c) using Method 2 will decrease the odds of detecting an increase in loadings. It is important to note that large differences in CVs between parameters, and any CVs that are larger than 2, are cause for concern about the adequacy of the baseline data. In such cases, more baseline data may be needed, or one or more measurements or data records might be in error.

3.7 Coefficients of Variation of Baseline Loadings

To aid in the selection of the proper statistical method, REMSTAT will calculate the coefficients of variation (CVs) for all parameters for each discharge for a mine. REMSTAT calculates the CVs for each parameter by dividing the sample standard deviation by the sample mean, using all of the baseline sample information entered.

On the Baseline Calculations Information Screen (Figure 10 above) there are two option buttons associated with the Calculate button. To perform a preliminary calculation of the coefficients of variation, select the option button next to the sentence beginning with "Preliminary Calculation of coefficients. . ." After the coefficients of variation are calculated, the results are automatically shown on the screen or they can be viewed by selecting the "View CVs" button on the screen. Figure 11 shows the screen on which they are displayed.

Figure 11. Baseline Sample Loadings CV Screen



Discharge	Fe CV	Mn CV	TSS CV	Net Acidity CV	Opt 1 CV	Opt 2 CV	Opt 3 CV	Opt 4 CV
Hydro Unit# 1	0.63	0.95			0.56			
MP-1	0.98	0.87						

3.8 Baseline Calculations -- Baseline Statistics

Section 3.6 stated the requirement that statistical methods for the single observation and annual tests be selected prior to baseline statistics calculation. REMSTAT provides a default of the generally recommended Method 1 for both tests. User action is required only if it is determined that Method 2 is appropriate for one or both tests.

In addition, the user also must also define the start and end dates for the annual test period for each pre-existing discharge or hydrologic unit. Different annual periods can be defined for each discharge or hydrologic unit.

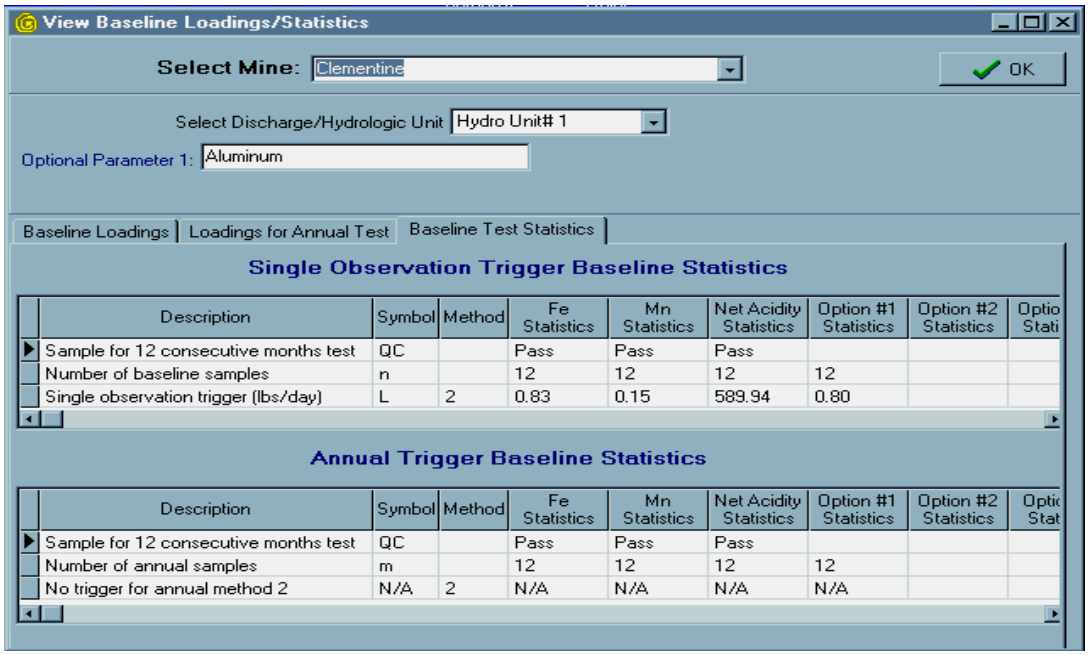
<u>Note:</u> The dates selected affect only the calculation of the annual test statistics. The annual period begins and ends on the dates specified in the Baseline Calculation Information Screen. All data that have been entered as baseline will be used in the determination of the single observation limit statistics.

To calculate baseline statistics, select the "Option" button for the second Calculation Type option and select the Calculate button.

Prior to baseline calculations, REMSTAT will test the baseline data set to determine if at least one sample per month for a period of twelve months is available (See Appendix B to 40 CFR part 434).

The results of the baseline calculations can be viewed by selecting the "View Baseline Loads/Stats" button on the Baseline Samples Menu (see Figure 5). Next, select the "Baseline Test Statistics" tab near the top of the screen and a screen like the one shown in Figure 12 will open.

Figure 12. Baseline Statistics Screen



Description	Symbol	Method	Fe Statistics	Mn Statistics	Net Acidity Statistics	Option #1 Statistics	Option #2 Statistics	Optio Stati
Sample for 12 consecutive months test	QC		Pass	Pass	Pass			
Number of baseline samples	n		12	12	12	12		
Single observation trigger (lbs/day)	L	2	0.83	0.15	589.94	0.80		

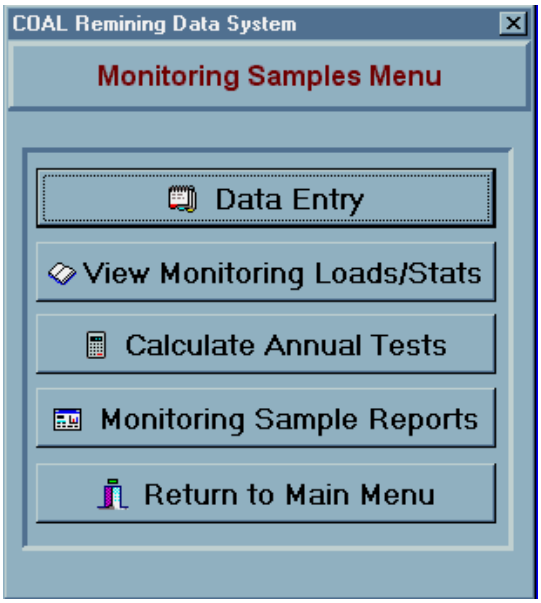
Description	Symbol	Method	Fe Statistics	Mn Statistics	Net Acidity Statistics	Option #1 Statistics	Option #2 Statistics	Optic Stat
Sample for 12 consecutive months test	QC		Pass	Pass	Pass			
Number of annual samples	m		12	12	12	12		
No trigger for annual method 2	N/A	2	N/A	N/A	N/A	N/A		

<u>Note:</u> Before continuing to the next phase (Exceedance Monitoring), the user should verify that all baseline information is complete and accurate for each discharge.

4.0 EXCEEDANCE MONITORING

The discharge/hydrologic unit information does not need to be re-entered for the monitoring phase. The program assumes the same discharges that were entered for baseline calculations will be evaluated during exceedance monitoring. To begin entering monitoring data, the user selects "Monitoring Samples" from the Opening Menu (Figure 1). The Monitoring Samples Menu is shown in Figure 13.

Figure 13. Monitoring Samples Menu



Selecting the "Data Entry" button will open the Monitoring Sample Data Screen. The Monitoring Sample Data Screen can be viewed in grid or "spreadsheet" form (see Figure 14). Also, the same screen can be viewed in form view (see Figure 15). Discharge monitoring data are entered in the same way as the baseline data (refer to Section 3.2). During monitoring data entry, loadings are calculated for individual discharges (and aggregated if necessary for hydrologic units) each time the user saves or leaves a sample date (See Section 4.1).

Figure 14. Grid View of Monitoring Sample Data Entry Screen

Discharge/Hydrologic Unit Monitoring Sample Data

Select Mine: Clementine

OK

Select Discharge: MP-1

Hydrologic Unit: Hydro Unit# 1

Optional Parameter 1: Aluminum

Form | Grid | Monitoring Data Entry

(Note: Reported loads for any parameter can be entered; if not entered, loads will automatically be calculated from concentration)

Sample Date	Sampling Cycle	Flow (gpm)	Field pH	Lab pH	Fe Flag (<)	Fe Concentration (mg/L)	Fe Load (lbs/day)	Mn Flag (<)	Mn Concentration (mg/L)	Mn Load (lbs/c
03/03/20	Monthly	12	3.6	4.85		0.65	0.09		0.08	
04/04/2002	Monthly	22	5.4	5.23		0.88	0.23		0.12	
05/05/2002	Monthly	18	5.3	5.85		0.26	0.06		0.08	
06/06/2002	Monthly	22	5.5	5.98		0.24	0.06		0.09	
07/07/2002	Monthly	55	5.8	6.25		0.15	0.10		0.08	
08/08/2002	Monthly	26	5.2	5.85		0.27	0.08		0.09	
09/09/2002	Monthly	56	5.2	5.9		0.15	0.10		0.05	
10/10/2002	Monthly	52	5.3	5.85		0.19	0.12		0.08	
10/17/2002	Weekly	25								
10/24/2002	Weekly	15								
11/01/2002	Weekly	8.9								
11/11/2002	Weekly	9.8	5.6	6.23		0.25	0.03		0.09	
12/12/2002	Monthly	8.7	5.5	5.98		0.35	0.04		0.05	

Figure 15. Form View of Monitoring Sample Data Entry Screen

Discharge/Hydrologic Unit Monitoring Sample Data

Select Mine: Clementine

OK

Select Discharge: MP-1

Hydrologic Unit: Hydro Unit# 1

Optional Parameter 1: Aluminum

Form | Grid | Monitoring Data Entry

Date: 03/03/2002 Sampling Cycle: Monthly Field pH: 3.6 Lab pH: 4.85 Flow (gpm): 12

Parameter	Concentration Flag (MV,<)	Concentration (mg/L)		Loading (lbs/day)
Iron (Fe)		0.65		0.09
Manganese (Mn)		0.08		0.01
Acidity		697	(CaCO3)	100.54
Alkalinity		0	(CaCO3)	0.00
Net Acidity (Calculated)		697	(CaCO3)	100.54
Total Suspended Solids (TSS)		12		1.73
Optional Parameter No. 1		0.08		0.01
Optional Parameter No. 2				
Optional Parameter No. 3				
Optional Parameter No. 4				

Comments

4.1 Single Observation Exceedance Check

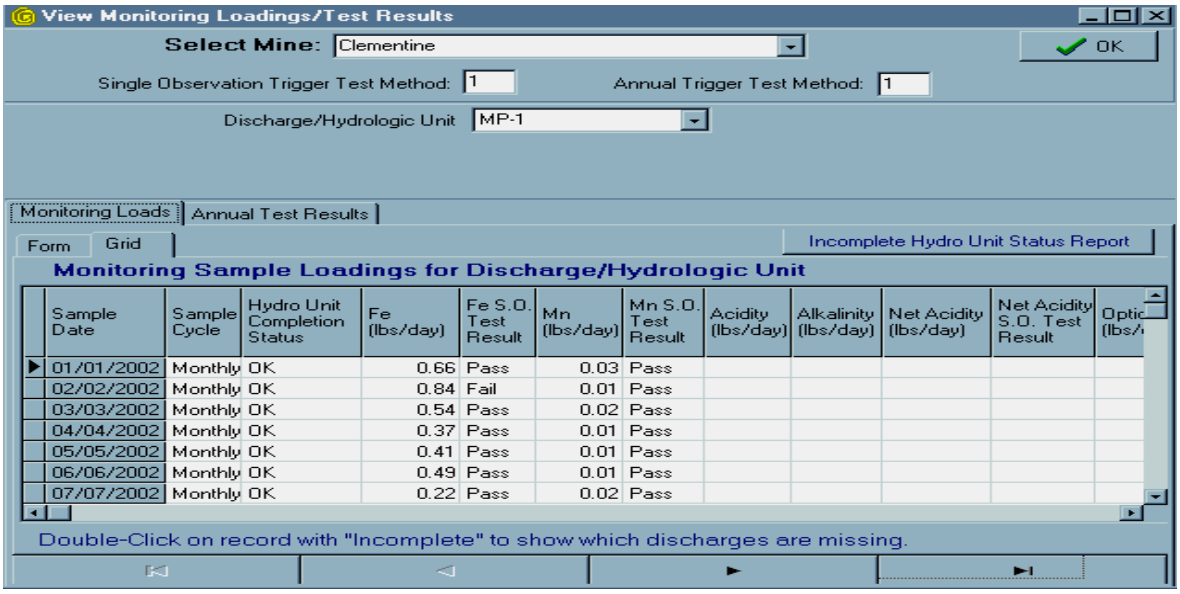
The rules for monitoring data entry are similar to those defined for baseline data entry (refer to Section 3.2). The primary difference is that REMSTAT assumes that all monitoring data will be entered chronologically. (Note: Data associated with a given date for a discharge or hydrologic unit must be entered before entering data that is associated with the next chronological date).

Once the user enters all the available data for a sample date and leaves a record (i.e., leaves a sample date in the grid view or form view for a given discharge), the program automatically calculates the following information:

- Pollutant mass load
- Aggregation of pollutant mass loads from all discharges within a hydrologic unit
- Comparison of mass loads with baseline Single Observation Triggers

Once monitoring data entry is complete, the user selects the "OK" button and returns to the Monitoring Samples Menu. To view monitoring statistics, select the "View Monitoring Loads/Stats" button and the View Monitoring Loadings Screen will open (Figure 16).

Figure 16. View Monitoring Loadings Screen



Sample Date	Sample Cycle	Hydro Unit Completion Status	Fe (lbs/day)	Fe S.O. Test Result	Mn (lbs/day)	Mn S.O. Test Result	Acidity (lbs/day)	Alkalinity (lbs/day)	Net Acidity (lbs/day)	Net Acidity S.O. Test Result	Optic (lbs/
01/01/2002	Monthly	OK	0.66	Pass	0.03	Pass					
02/02/2002	Monthly	OK	0.84	Fail	0.01	Pass					
03/03/2002	Monthly	OK	0.54	Pass	0.02	Pass					
04/04/2002	Monthly	OK	0.37	Pass	0.01	Pass					
05/05/2002	Monthly	OK	0.41	Pass	0.01	Pass					
06/06/2002	Monthly	OK	0.49	Pass	0.01	Pass					
07/07/2002	Monthly	OK	0.22	Pass	0.02	Pass					

In this screen, REMSTAT performs the following quality control checks:

- If corresponding dates have not been entered for all discharges within a hydrologic unit, an "Incomplete" will be indicated for the date(s) in question in the "Completion Status" column.

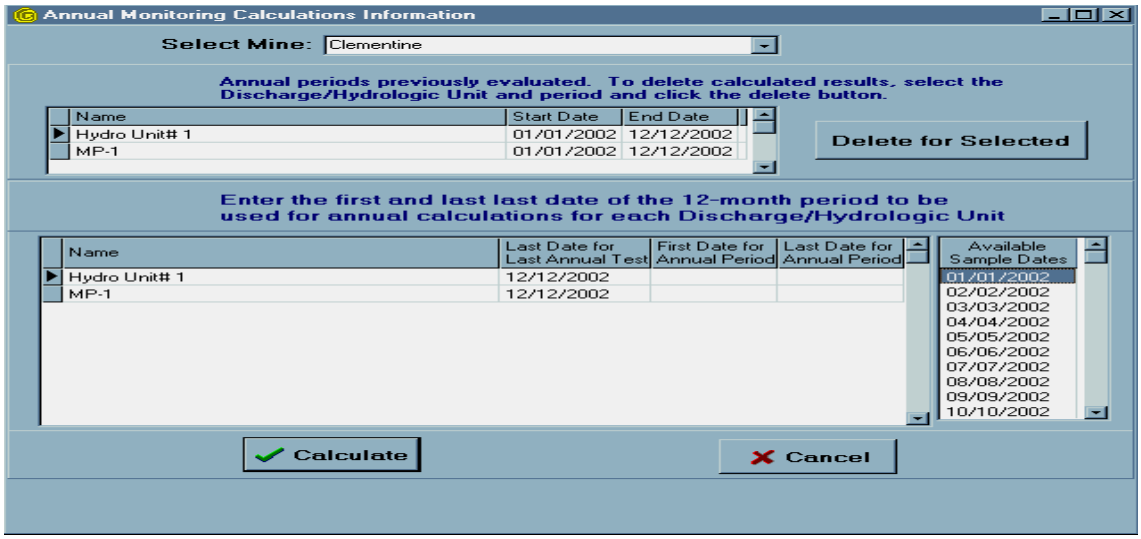
- All exceedances of the Single Observation Trigger will be indicated by a "Fail" in a "S.O. (Single Observation) Test Result" column.

4.2 Annual Exceedance Check

Both Test Method 1 and Test Method 2 require that the data collected during the first year, and for all subsequent years, be statistically analyzed and compared to the baseline Annual Trigger to determine if the data sets are significantly different. The details of this annual test can be found in Appendix B of the January 23, 2002 final rule (67 FR 3370) and Appendix A of the Coal Remining Statistical Support Document (EPA-821-B-01-012). Examples are also provided in Appendix A to this Manual.

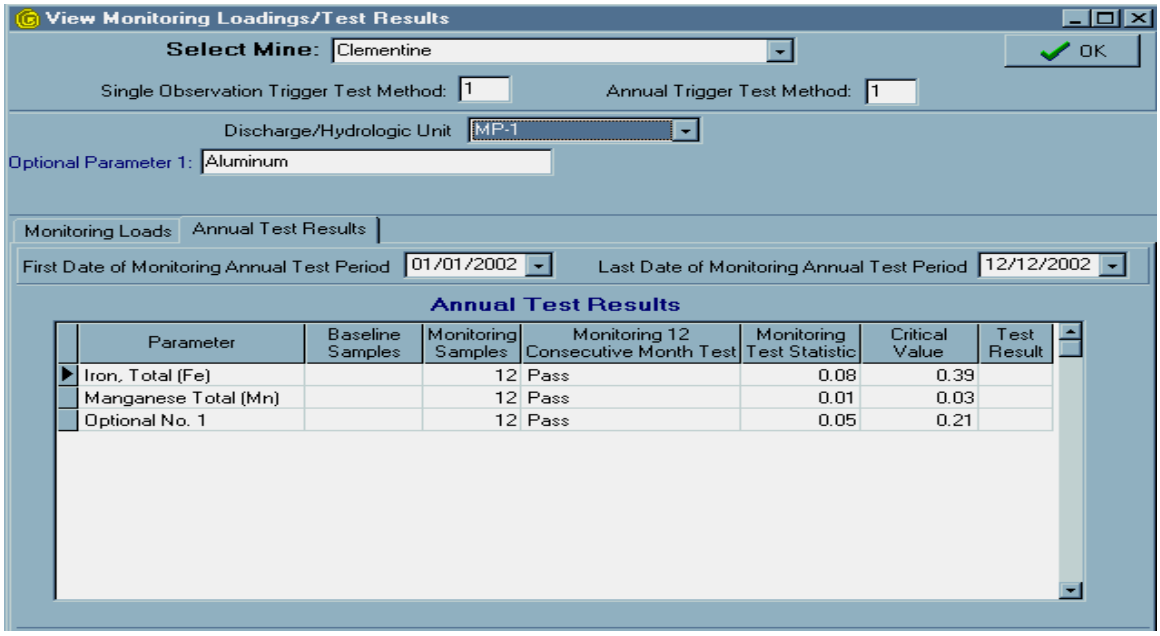
If the user selects the "Calculate Annual Test" button in the Monitoring Samples Menu, the Annual Monitoring Calculation Screen will open (Figure 17). The user can define the annual period by entering the first and last sample dates to be included in the annual test. If the user then selects the "Calculate" button, the program will automatically compare the annual test statistics to the baseline year statistics and report, using an exceedence ("Fail") flag, if the annual monitoring period yields pollution loading that is determined to be significantly higher than baseline annual trigger.

Figure 17. Annual Monitoring Calculation Information



The annual results can be viewed by selecting the "View Monitoring Loads/Stats" button in the Monitoring Samples Menu and then selecting the "Annual Test Results" tab (see Figure 18). A summary of the annual test results are reported in table form.

Figure 18. Monitoring Loadings Annual Test Results



Parameter	Baseline Samples	Monitoring Samples	Monitoring 12 Consecutive Month Test	Monitoring Test Statistic	Critical Value	Test Result
Iron, Total (Fe)		12	Pass	0.08	0.39	
Manganese Total (Mn)		12	Pass	0.01	0.03	
Optional No. 1		12	Pass	0.05	0.21	

4.3 Weekly Monitoring

If two consecutive monthly monitoring observations for a required parameter exceed the Single Observation Limit (L), the mine should immediately begin weekly monitoring for a period of four weeks for each parameter that had consecutive monthly exceedances. If three or fewer of the weekly observations exceed L, the mine can resume monthly monitoring. If all four weekly observations exceed L, the baseline pollution loading has been exceeded.

Entry of weekly monitoring data is the same as that for monthly samples, except the user must change the "Sampling Cycle" to Weekly instead of Monthly during data entry (refer to Figure 14). Although REMSTAT does not require the user to report weekly samples, REMSTAT will remind the user when weekly sampling is required (i.e., after two consecutive monthly samples exceed a baseline Single observation Trigger).

Note: When the sampling intervals revert from weekly back to monthly, the user needs to reset the sampling cycle from weekly to monthly (in grid view or form view, Figures 14 and 15). REMSTAT will not do this automatically.

5.0 REPORT GENERATION

REMSTAT is able to generate three types of baseline reports and two types of monitoring reports. The types of reports are as follows:

Baseline Reports
- Baseline Sample Data
- Baseline Loadings
- Baseline Statistics

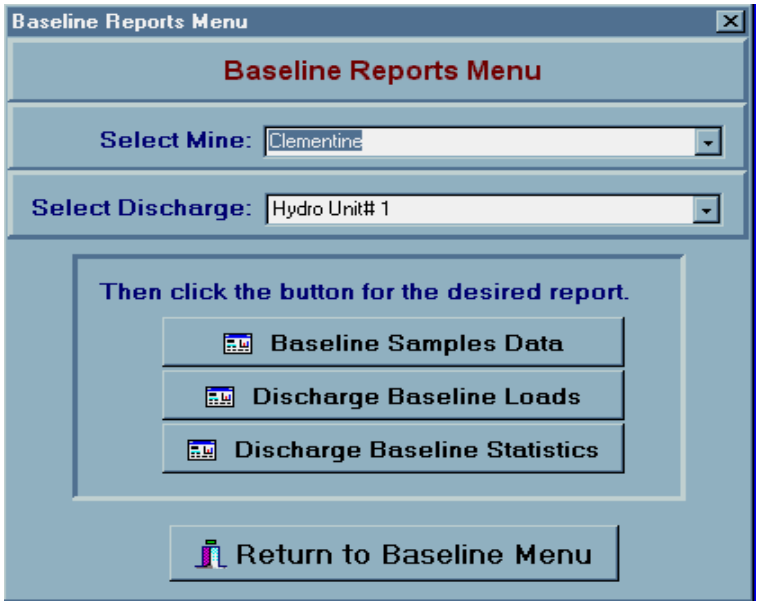
Monitoring Reports
- Single Observation Analysis
- Annual Test Results

Baseline and Exceedance Monitoring Reports are discussed in detail in Section 5.1 and 5.2, respectively.

5.1 Baseline Reports

Baseline reports can be viewed by selecting "Baseline Samples" in the opening menu, and then "Baseline Reports" in the "Baseline Samples Menu". After the "Baseline Reports" button is selected, a screen like the one shown in Figure 19 is displayed.

Figure 19. Baseline Reports Menu



An example of the Baseline Sampling Data Report is shown in Figure 20. The Baseline Samples Data Report provides the user with a hard copy printout of the same data that can be viewed in the Baseline Data Entry Screen. The mass load equivalents calculated from concentration and flow data also are provided.

Figure 20. Baseline Samples Data Report

Mine: Clementine
Discharge/Hydrologic Unit: MP-1
SMCRA Permit No.: 222-1054
NPDES Permit No.: WV004856

09/27/20

Baseline Samples Data Report

Monitoring/Sampling Point: MP-1

				Total Iron (Fe)			Manganese (Mn)			Acidity			Alkalinity		
Date Sampled	Flow (gpm)	Field pH	Lab pH	Data Flag	Conc. (mg/L)	Load (lbs/day)	Data Flag	Conc. (mg/L)	Load (lbs/day)	Data Flag	Conc. (mg/L)	Load (lbs/day)	Data Flag	Conc. (mg/L)	Load (lbs/day)
01/01/2001	22.00				0.05	0.01		0.05	0.01						
02/02/2001	18.00				0.95	0.21		0.05	0.01						
03/03/2001	10.00				1.25	0.15		0.05	0.01						
04/04/2001	78.00				1.69	1.58		0.05	0.05						
05/05/2001	9.40				5.97	0.67		0.05	0.01						
06/06/2001	22.80				4.98	1.36		0.05	0.01						
07/07/2001	56.70				2.36	1.61		0.05	0.03						
08/08/2001	24.00				3.75	1.08		0.05	0.01						
09/09/2001	32.50				2.50	0.98		0.05	0.02						
10/10/2001	10.00				6.20	0.75		0.05	0.01						
11/11/2001	90.00				3.70	4.00		0.05	0.05						
12/12/2001	35.00				5.50	2.31		0.05	0.02						

The Discharge Baseline Loadings Report provides the user with the loadings calculated for each single pre-existing discharge or the aggregated loadings for each hydrologic unit. An example of the Discharge Baseline Loadings Report is shown in Figure 21. This report provides the user with a copy of the data that are presented in the Baseline Loadings Statistics Screen (Figure 9).

Figure 21. Baseline Loadings Report

Mine: Clementine
Discharge/Hydrologic Unit: MP-1
SMCRA Permit No.: 222-1054
NPDES Permit No.: WV004856

Discharge Baseline Loads Report

		Discharge Mass Loads (lbs/day)			
Date Sampled	Included for Annual Test*	Total Iron (Fe)	Manganese (Mn)	Net Acidity	Aluminum (Opt. 1)
01/01/2001	Yes	0.01	0.01		1.72
02/02/2001	Yes	0.21	0.01		4.87
03/03/2001	Yes	0.15	0.01		2.76
04/04/2001	Yes	1.58	0.05		42.19
05/05/2001	Yes	0.67	0.01		6.21
06/06/2001	Yes	1.36	0.01		6.44
07/07/2001	Yes	1.61	0.03		30.67
08/08/2001	Yes	1.08	0.01		6.35
09/09/2001	Yes	0.98	0.02		5.86
10/10/2001	Yes	0.75	0.01		1.20
11/11/2001	Yes	4.00	0.05		8.65
12/12/2001	Yes	2.31	0.02		2.94

* Included for annual test applicable only after baseline statistics have been calculated

The Baseline Statistics Report (Figure 22) provides the user with a hard copy summary of baseline statistics generated for each pre-existing discharge/hydrologic unit for the Method selected (i.e., Method 1 or Method 2). This report contains the same information presented in the View Baseline Loadings/Statistics Screen (Figure 12). The report presents the results of :

Single Observation Test Statistics and Triggers

- Results of Hydrologic Unit Completeness Test
- Number of Available Baseline Samples
- Single Observation Limit (L)

Annual Test Statistics and Triggers

- Results of Completeness Test
- Number of Annual Samples
- Annual Trigger (T)

An example of the Baseline Discharge Statistics table is shown in Figure 22.

Figure 22. Baseline Statistics Report

Mine: Clementine 01/10/2003
Discharge/Hydrologic Unit: MP-1
SMCRA Permit No.:
NPDES Permit No.:

Discharge Baseline Statistics Report

1. Single Observation Test Statistics and Triggers **Method Used:** 1

Parameter	Completeness Test *	Number of Baseline Samples	Single Obs. Limit (L) [lbs/d]
Iron, Total (Fe)	Pass	12	0.72
Manganese Total (Mn)	Pass	12	0.04
Net Acidity			
Aluminum (Opt. 1)	Pass	12	0.59

2. Annual Test Baseline Stastics and Test Parameters **Method Used:** 1

Parameter	Completeness Test *	Number of Annual Test Samples	Annual Trigger (T)[lbs/d]
Iron, Total (Fe)	Pass	12	0.39
Manganese Total (Mn)	Pass	12	0.03
Net Acidity			
Aluminum (Opt. 1)	Pass	12	0.21

* Completeness Test = Provides at least one sample per month for a period of 12 months

5.2 Monitoring Reports

After entry of monitoring data, the program can generate reports for the Single Observation and Annual tests. Monitoring reports can be accessed by selecting the "Monitoring Samples" button on the opening screen, then selecting the "Monitoring Samples Reports" button. After the "Monitoring Samples Report" button is selected a form like the one shown in Figure 23 is displayed.

Figure 23. Monitoring Reports Screen

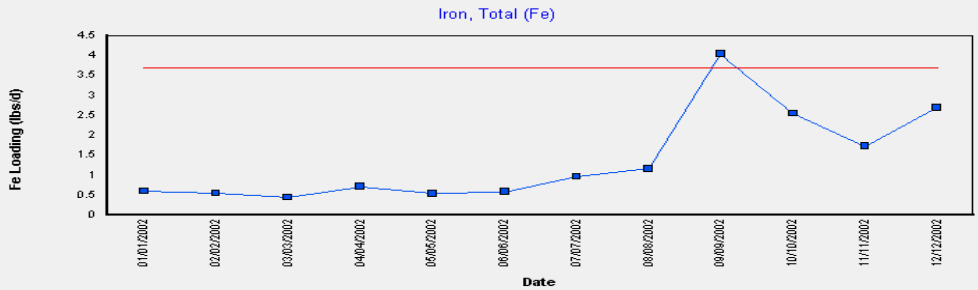
By default, the Monitoring Reports menu opens with the options for the Single Observation Analysis. The user makes sure the correct mine and discharge or hydrologic unit are selected, then selects the check boxes to have REMSTAT prepare a Single Observation Report for that parameter. There will be a check box for each of the named parameters and any optional parameters the user specified for the discharge. Selecting the Single Observation Analysis button produces a report like the one shown in Figure 24.

Figure 24. Example - Single Observation Monitoring Report

Mine: Clementine
Discharge Point: Hydro Unit# 1
SMCRA Permit No.:
NPDES Permit No.:

01/06/2003

Exceedance Monitoring
Single Observation Analysis



Sample Date	Sample Cycle	Iron, Total (Fe) Loading (lbs/d)	SO Trigger Test Results
01/01/2002	Monthly	0.61	Pass
02/02/2002	Monthly	0.55	Pass
03/03/2002	Monthly	0.45	Pass
04/04/2002	Monthly	0.71	Pass
05/05/2002	Monthly	0.54	Pass
06/06/2002	Monthly	0.58	Pass
07/07/2002	Monthly	0.97	Pass
08/08/2002	Monthly	1.16	Pass
09/09/2002	Monthly	4.04	Fail
10/10/2002	Monthly	2.55	Pass
11/11/2002	Monthly	1.73	Pass
12/12/2002	Monthly	2.69	Pass

Method 1 Single Observation Trigger = 3.70

By selecting the "Annual Monitoring" tab on the Monitoring Reports Menu, a screen like the one shown in Figure 25 opens.

Figure 25. Annual Monitoring Reports Screen

The user selects the appropriate mine, discharge, and start and end dates for the annual period the user wishes to evaluate. If the user selects the "Annual Monitoring" button, a report like the one shown in Figure 26 opens.

Figure 26. Example - Annual Monitoring Report

Mine: Clementine 01/06/2003
Discharge/Hydrologic Unit: Hydro Unit# 1
SMCRA Permit No.:
NPDES Permit No.:

Annual Exceedance Monitoring

Period Starting: 01/01/2002 Period Ending : 12/12/2002

Method 1

Parameter	Baseline Test Statistic (T)	Number of Monitoring Samples	12 Consecutive Months Test	Monitoring Test Value (T')	Exceedances
Iron, Total (Fe)	2.68	12	Pass	0.42	
Manganese	0.14	12	Pass	0.01	
Optional No. 1	2.45	12	Pass	0.06	
Note: If T' ≤ T, the median baseline pollution load was not exceeded.					

Appendix A

Example Calculations of Statistical Procedures

The following calculations are examples of the statistical procedures used by REMSTAT. These examples also are provided in Appendix A to the U.S. Environmental Protection Agency's Coal Remining Statistical Support Document (EPA 821-B-01-001).

1. Example 1 includes concentration and flow results for 12 baseline and monitoring samples. This example presents application of both Method 1 and Method 2, using the steps defined for 12 samples.
2. Example 2 includes loading results for 18 baseline and monitoring samples. This example presents application of both Method 1 and Method 2, and includes the calculation of the Single Observation Trigger specified for 17 samples or greater in Method 1.

A1.0 Example 1

Assume 12 baseline flow and iron concentrations are collected by sampling once per month for a year. Likewise, 12 flow and iron monitoring observations are obtained by sampling once per month for a period of one year. Determination of exceedances are presented using both Methods 1 and 2. For all calculations in Example 1, assume the following flows (in gpm) and iron concentrations (in mg/L).

Flow

Baseline	5.0	14.0	42.0	35.0	26.0	22.0	12.0	11.0	11.0	6.0	11.0	6.0
Monitoring	8.0	14.0	15.0	32.0	43.0	28.0	16.0	14.0	16.0	9.0	9.0	11.0

Iron Concentration

Baseline	14.2	14.0	20.6	13.6	13.2	12.4	13.2	13.4	13.6	14.3	15.2	13.4
Monitoring	16.2	17.8	16.3	15.1	20.9	15.7	15.8	16.7	15.4	15.6	16.7	15.3

The resulting iron loads (in lbs/day = flow * concentration * 0.01202) are given below:

Iron Loads

Baseline	0.85	2.36	10.40	5.72	4.13	3.28	1.90	1.77	1.80	1.03	2.01	0.97
Monitoring	1.56	3.00	2.94	5.81	10.80	5.28	3.04	2.81	2.96	1.69	1.81	2.02

A1.1 Single Observation Trigger

A1.1.1 Method 1

1) Twelve baseline observations were collected, therefore n = 12.

2) The baseline loading observations are placed in sequential order from smallest to largest. [0.85, 0.97, 1.03, 1.77, 1.80, 1.90, 2.01, 2.36, 3.28, 4.13, 5.72, 10.40]

3) The number of observations, n, is less than 16, therefore the Single Observation Trigger (L) equals $x_{(12)}$ (the maximum) = 10.40.

4) One monitoring load (10.80) is greater than 10.40, therefore the Single Observation Trigger (L) was exceeded.

A1.1.2 Method 2

1) Twelve is an even number, therefore the median of the modified baseline observations is:
   $M = 0.5 * (x_{(6)} + x_{(7)})$.
   $M = 0.5 * (1.90 + 2.01) = 1.955$

   In order to determine M_1, calculate the median of the subset ranging from $x_{(7)}$ to $x_{(12)}$. Because 12 - 6 = 6 is even, $M_1 = 0.5 * (x_{(9)} + x_{(10)})$
   $M_1 = 0.5 * (3.28 + 4.13) = 3.705$

2) In order to determine M_{-1}, calculate the median of the subset ranging from $x_{(1)}$ to $x_{(6)}$. Because 6 is even, $M_{-1} = 0.5 * (x_{(3)} + x_{(4)})$
   $M_{-1} = 0.5 * (1.03 + 1.77) = 1.40$

3) To calculate R, subtract M_{-1} from M_1.
   R = 3.705 - 1.40 = 2.305

4) $L = M_1 + (3 * R) = 3.705 + (3 * 2.305) = 10.62$

5) One monitoring observation (10.80) is greater than 10.62, therefore the Single Observation Trigger (L) was exceeded.

A1.2 Annual Comparison

A1.2.1 Method 1

1) From 1.1.2 Step 1, $M_1 = 3.705$

2) From 1.1.2 Step 2, $M_{-1} = 1.40$

3) From 1.1.2 Step 3, R = 2.305

4) The calculated value for R is then substituted into the equation for T.

$$T = 1.955 + \frac{1.815 * 2.305}{\sqrt{12}} = 3.16$$

5) The following monitoring observations are ordered from smallest to largest.
[1.56, 1.69, 1.81, 2.02, 2.81, 2.94, 2.96, 3.00, 3.04, 5.28, 5.81, 10.80]

6) There are 12 monitoring observations, therefore m = 12.
The number of observations is even, therefore $M' = 0.5 * (x_{(6)} + x_{(7)})$
$M' = 0.5 * (2.94 + 2.96) = 2.95$
This holds true for M_1' and M_{-1}' as well.
$M_1' = 0.5 * (x_{(9)} + x_{(10)}) = 0.5 * (3.04 + 5.28) = 4.16$
$M_{-1}' = 0.5 * (x_{(3)} + x_{(4)}) = 0.5 * (1.81 + 2.02) = 1.915$

7) To calculate R, subtract M_{-1}' from M_1'
$R' = 4.16 - 1.915 = 2.245$.

8) The calculated value for R' is then substituted in the equation for T '.

$$T' = 2.95 - \frac{1.815 * 2.245}{\sqrt{12}} = 1.77$$

9) T' (1.77) is less than T (3.16), therefore the median baseline pollution loading was not exceeded.

A1.2.2 Method 2 (Wilcoxon-Mann-Whitney Test)

Instructions for the Wilcoxon-Mann-Whitney test are given in Conover (1980), and cited in EPA's Coal Remining Statistical Support Document.

1) When using both baseline and monitoring data, n = 12 and m =12
2) The baseline and monitoring observations are listed with their corresponding rankings.

Baseline Obs. (lbs/day)	0.85	0.97	1.03	1.77	1.80	1.90	2.01	2.36	3.28	4.13	5.72	10.40
Baseline Rankings	1	2	3	6	7	9	10	12	18	19	21	23
Monitoring Obs. (lbs/day)	1.56	1.69	1.81	2.02	2.81	2.94	2.96	3.00	3.04	5.28	5.81	10.80
Monitoring Rankings	4	5	8	11	13	14	15	16	17	20	22	24

3) The sum of the twelve baseline ranks (S_n) = 131.
4) In order to find the appropriate critical value (C), match the column with the correct n (number of baseline observations) to the row with the correct m (number of monitoring observations). As found in the table, the critical value C for 12 baseline and 12 monitoring observations is 99.

Critical Values (C) of the Wilcoxon-Mann-Whitney Test
(for a one-sided test at the 99.9 percent level)

m \ n	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
10	66	79	93	109	125	142	160	179	199	220	243
11	68	82	96	112	128	145	164	183	204	225	248
12	70	84	99	115	131	149	168	188	209	231	253
13	73	87	102	118	135	153	172	192	214	236	259
14	75	89	104	121	138	157	176	197	218	241	265
15	77	91	107	124	142	161	180	201	223	246	270
16	79	94	110	127	145	164	185	206	228	251	276
17	81	96	113	130	149	168	189	211	233	257	281
18	83	99	116	134	152	172	193	215	238	262	287
19	85	101	119	137	156	176	197	220	243	268	293
20	88	104	121	140	160	180	202	224	248	273	299

5) S_n (131) is greater than C (99). Therefore, according to the Wilcoxon-Mann-Whitney Test, the monitoring observations did not exceed the baseline pollution loading.

A2.0 Example 2

Assume 18 baseline iron loading determination observations are collected by sampling twice per month for nine months. Likewise, 18 iron load monitoring observations are obtained by sampling twice per month for a period of nine months. Examples of both Methods 1 and 2 are presented below. For all calculations in Example 2, assume the following iron load observations (in lbs/day):

Observation	Baseline	Monitoring
1	0.030	0.530
2	0.005	0.040
3	1.915	1.040
4	0.673	0.033
5	0.064	0.030
6	0.063	0.230
7	0.607	0.710
8	0.553	0.240
9	0.286	0.390
10	0.106	0.830
11	0.406	3.050
12	1.447	0.580
13	0.900	1.180
14	0.040	0.510
15	2.770	0.046
16	1.803	0.690
17	0.160	0.630
18	0.045	0.370

A2.1 Single Observation Trigger

A2.1.1 Method 1

1) The number of baseline observations collected, n = 18.

2) The baseline observations are ordered sequentially from smallest to largest. [0.005, 0.030, 0.040, 0.045, 0.063, 0.064, 0.106, 0.160, 0.286, 0.406, 0.553, 0.607, 0.673, 0.900, 1.447, 1.803, 1.915, 2.770]

3) The number of observations is greater than 16, therefore M, M_1, M_2 and M_3 must be calculated. The number of observations is even, which means the median of the baseline observations must be calculated using the following equation:
   $M = 0.5 * (x_{(9)} + x_{(10)})$.
   $M = 0.5 * (0.286 + 0.406) = 0.346$

4) To determine M_1, calculate the median of the subset ranging from $x_{(10)}$ to $x_{(18)}$.
   18 - 9 = 9 is odd, therefore $M_1 = x_{(14)} = 0.900$.

5) To determine M_2, calculate the median of the subset ranging from $x_{(14)}$ to $x_{(18)}$.
   18 - 13 = 5 is odd, therefore $M_2 = x_{(16)} = 1.803$.

6) To determine M_3, calculate the median of the subset ranging from $x_{(16)}$ to $x_{(18)}$.
   18 - 15 = 3, which is odd, therefore $M_3 = x_{(17)} = 1.915$.

7) To determine L, calculate the median of the subset ranging from $x_{(17)}$ to $x_{(18)}$.
   18 - 16 = 2, which is even, therefore $L = 0.5 * (x_{(17)} + x_{(18)}) = 0.5 * (1.915 + 2.770) = 2.343$.

8) One monitoring observation (3.050) is above L (2.343), therefore the Single Observation Trigger was exceeded.

A2.1.2 Method 2

1) From 2.1.1 Step 4, M_1 (the third quartile of the baseline data) is equal to 0.900.

2) To find M_{-1}, calculate the median of the subset ranging from $x_{(1)}$ to $x_{(9)}$.
   9 is odd, therefore $M_{-1} = x_{(5)} = 0.063$.

3) The value for R is found by subtracting M_{-1} from M_1
   R = 0.900-0.063 = 0.837

4) $L = M_1 + (3 * R) = 0.900 + (3 * 0.837) = 3.411$.

5) All monitoring observations are less than 3.411, therefore the Single Observation Trigger (L) was not exceeded.

A2.2 Annual Comparison

A2.2.1 Method 1

1) As determined in Section 2.1.2 step 1, M = 0.346, and M_1 = 0.900.

2) As determined in Section 2.1.2 step 2, M_{-1} = 0.063.

3) As determined in Section 2.1.2 step 3, R = 0.837.

4) To find T, the value for R is inserted in the following equation:

$$T = 0.346 + \frac{1.815 * 0.837}{\sqrt{18}} = 0.704$$

5) The monitoring observations are placed in order from lowest to highest.
[0.030, 0.033, 0.040, 0.046, 0.230, 0.240, 0.370, 0.390, 0.510, 0.530, 0.580, 0.630, 0.690, 0.710, 0.830, 1.040, 1.180, 3.050]

6) The number of monitoring observations (m) = 18.
18 is even, making M' = 0.5 * ($x_{(9)}$ + $x_{(10)}$)
M' = 0.5 * (0.510 + 0.530) = 0.520

7) To determine M_1', calculate the median of subset $x_{(10)}$ to $x_{(18)}$.
Because 18 - 9 = 9 is odd, M_1' = ($x_{(14)}$) = 0.710

8) To determine M_{-1}', calculate the median of subset $x_{(1)}$ to $x_{(9)}$.
Because 9 is odd, M_{-1}' = ($x_{(5)}$) = 0.230

9) The value for R' is found by subtracting M_{-1}' from M_1'.
R' = 0.710 - 0.230 = 0.48

10) To find T ', the value for R' is inserted into the following equation:

$$T' = 0.520 - \frac{1.815 * 0.48}{\sqrt{18}} = 0.315$$

11) T ' (0.315) is less than T (0.704), therefore the median baseline pollution loading is not exceeded.

A2.2.2 Method 2 (Wilcoxon-Mann-Whitney Test)

Instructions for the Wilcoxon-Mann-Whitney test are given in Conover (1980) and cited in EPA's Coal Remining Statistical Support Document.

1) When using both baseline and monitoring data, n = 18 and m = 18.

2) The baseline and monitoring observations are listed in order of collection, and ranked as follows:

Baseline Observations		**Monitoring Observations**	
(lbs/day)	(Ranking)	(lbs/day)	(Ranking)
0.030	2.5	0.530	20
0.005	1	0.040	6
1.915	34	1.040	30
0.673	25	0.033	4
0.064	10	0.030	2.5
0.063	9	0.230	13
0.607	23	0.710	27
0.553	21	0.240	14
0.286	15	0.390	17
0.106	11	0.830	28
0.406	18	3.050	36
1.447	32	0.580	22
0.900	29	1.180	31
0.040	5	0.510	19
2.770	35	0.046	8
1.803	33	0.690	26
0.160	12	0.630	24
0.045	7	0.370	16

The value of 0.030 was obtained for more than one observation. The ranking displayed is the average of 2 and 3 (2.5).

3) The sum of the 18 baseline ranks (S_n) = 322.5.

4) From the table in section 1.2.2 of this appendix, the critical value (C) for 18 baseline and 18 monitoring observations is 238.

5) S_n (322.5) is greater than the critical value C (238). Therefore, according to the Wilcoxon-Mann-Whitney test, the monitoring observations did not exceed the baseline pollution loading.