Pennichuck Watershed Restoration Project:

Water Quality Assessment

Quality Assurance Project Plan

January 31, 2006

Prepared by

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For

Department of Environmental Protection s.319 Nonpoint Source Pollution Grant Program:

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NH DES Program QA Coordinator	Jillian Jones, NH DES	Date
NH DES Quality Assurance Manager	Vincent Perelli, NH DES	Date
U.S. EPA Project Manager	Warren Howard, U.S. EPA, Region 1	Date
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	G2: WL15 Level Logger Manual
H	Standard Operating Procedure for Streamflow Calculations
I	YSI 55 & Hanna HI 98128 Calibration Instructions
J	Chemserve Laboratory Materials
K	RI Analytical Laboratory Materials

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A4-1. Project/Task Organization

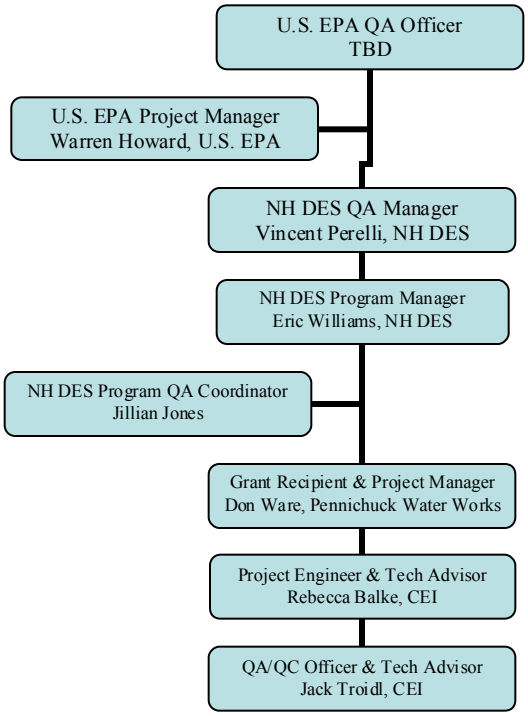


Figure A4-1. Project organization and coordination.

Project Manager & Grant Recipient

Mr. Don Ware is the project manager and is responsible for the overall management of the project. Mr. Ware is the grant recipient for NH DES s.319 Nonpoint Source Pollution Grant. Mr. Ware is the project contact and will coordinate and oversee each phase of the project with the appropriate project team personnel.

NH DES Program Manager

Mr. Eric Williams is the DES Program Manager. Mr. Williams is responsible for overall DES project grant management including technical and administrative supervision and final task review and approval.

NH DES Program QA Coordinator

Ms. Jillian Jones is the DES Program QA Coordinator. Ms. Jones will review and provide comment on the Quality Assurance Project Plan (QAPP). All modifications to the approved QAPP will be documented and submitted to Ms. Jones for approval, including but not limited to changes in sample design, sample collection, and data assessment and reporting.

NH DES Quality Assurance Manager

Mr. Vincent Perelli is the DES Quality Assurance Manager. Mr. Perelli will review and provide comment on the Quality Assurance Project Plan (QAPP). Ms. Jones will submit the QAPP and all modifications to Mr. Perelli.

U.S. EPA Project Manager

Mr. Warren Howard is the EPA Project Manager responsible for EPA Region 1 319 grant management for the state of New Hampshire. Mr. Howard is responsible for overall EPA grant management.

U.S. EPA QA Officer

The EPA QA Officer will review and provide comment on the Quality Assurance Project Plan (QAPP). All modifications to the approved QAPP will be documented and submitted to the EPA QA Officer for approval, including but not limited to changes in sample design, sample collection, and data assessment and reporting. The EPA QA officer will provide formal QAPP approval before project work can begin.

Project Engineer & Technical Advisor

Pennichuck Water Works has enlisted Comprehensive Environmental, Inc. (CEI) to assist with oversight of all tasks pertaining to the DES 319 grant. Ms. Rebecca Balke will serve as CEI's lead engineer as well as serve in a technical advisory role.

QA/QC Officer and Technical Advisor

Mr. Jack Troidl is responsible for QAPP revisions and submittals based on comments from the Project and QA Officers. Mr. Troidl will assist the Project Manager with technical and QA/QC components of the QAPP, as needed, throughout the sampling project as well as serve in a technical advisory capacity. He will ensure that all elements of the project follow the QA procedures in the QAPP including data quality objectives and reporting.

A5. Problem Definition/Background

The Pennichuck watershed lies in five Southern New Hampshire towns including Nashua, Merrimack, Amherst, Milford, and Hollis and covers approximately 18,000 acres, see Map A5-1 in Appendix A. The primary Pennichuck Water Works water supply consists of about 351 acres of water in a series of chain ponds that include Supply Pond, Harris Pond, Bowers Pond, and Holts Pond. Stump Pond, Pennichuck Pond, and many smaller ponds also contribute water to Pennichuck's supply. The total pond acreage is just under 2% of the total watershed area. The chain pond system experiences water quality problems and two of the ponds, Bowers Pond and Harris Pond are listed for excess algal growth on the states 303(d) list of impaired waterbodies. Excess algal growth is often tied to excessive phosphorus inputs. The ponds historically have experienced excessive nutrients in the form of phosphorus resulting in algal blooms and overall poor water quality.

Pennichuck Water Works has been actively involved in watershed protection activities since 1998, working closely with Comprehensive Environmental Inc. (CEI) to assess the Pennichuck Brook Watershed and develop best management practices (BMPs) to reduce pollution and

increase protection of the surface water supply. This began with the development of the "Pennichuck Water Works Watershed Management Plan" August 1998, which provided an initial overview of the characteristics and conditions of the watershed and chain pond system, including water quality of and phosphorus loadings to the chain pond system. The watershed plan was then followed by more detailed assessments of each of the nine subwatersheds identified in the original plan to examine problem areas and recommend improvements. Implementation of these recommendations is ongoing. Some of this work was performed with assistance from the NHDES Source Water Supply grant program.

Although Pennichuck Water has a 10-year Master Plan for the various subwatersheds, it does not include all of the elements of a restoration plan as outlined by NHDES to assist in providing information for future funding requests. Pennichuck is now proposing to develop a restoration plan that meets NHDES guidelines. This will be accomplished by building upon the information included in the existing plans and filling in the gaps to meet the NHDES guidelines. The development of this plan incorporates sampling and modeling of pollutant loadings into the water supply and pollutant reductions from existing BMPs to develop the best course of action and locations to implement additional measures to meet water quality goals. This QAPP addresses the necessary protocol for sampling and modeling to ensure the best results possible can be obtained.

A6. Project/Task Description

The objective of the Pennichuck Watershed Restoration Plan is to determine the total loadings to the ponds and the best ways to reduce these loadings to improve the water quality of the ponds. This involves the use of a pollutant loading model, which estimates pollutant loads from the watershed based on existing land uses. The model will then incorporate existing BMPs within the watershed to determine the reduction in loadings already taking place through existing measures. Sampling data will be collected and used to help calibrate the data as explained further below. Phosphorus and total suspended solids (TSS) will be the focus of the modeling and sampling efforts. Phosphorus was selected as an important parameter because it is the limiting nutrient for aquatic plants in freshwater systems and is responsible for the algal blooms observed in the ponds. TSS was selected because sediment loadings into the ponds decrease the ponds capacity, which was also noted to be a problem in the historic studies performed for the watershed. Table A6-1, the project schedule is shown on the following page.

Dry weather sampling of tributaries and ponds will be performed to obtain more information on the average pollutant concentrations in the pond and on the loadings coming from various areas of the watershed. The in-pond sampling provides information on the overall health of the lake. During the summer months, the lakes typically stratify into two or three thermal layers. Pond layers will be identified by taking temperature and dissolved oxygen readings at half meter increments. Due to differences in density and temperature in the layers, the chemistry may vary significantly between the layers. Therefore samples will be taken at three depths, just below the surface in the epilimnion, in the middle metalimnion layer, and a few inches above the bottom. If only 2 thermal layers are identified, then only surface and bottom samples will be taken. Parameters tested in tributary and in-pond locations include, color, specific conductance, total suspended solids (TSS), total dissolved solids (TDS), turbidity, alkalinity, phosphorous, nitrate, ammonia, total Kjeldahl nitrogen (TKN), chloride, iron, manganese and total organic carbon

(TOC). The pond locations will also be sampled for dissolved oxygen (DO), temperature and Secchi disk readings. The standard operating procedures for dry weather sampling and monitoring is included in Appendix E. This monitoring will build upon the previous monitoring completed by Pennichuck and provide a solid baseline of water quality data to which future changes can be compared. The TSS and phosphorus data will be used in the modeling analysis to help calibrate these loadings. Temperature and DO readings will be used to help analyze the stratification of the ponds and potential for internal phosphorus release. The other parameters will be used to track trends over a long term monitoring program.

Table A6-1. Project Schedule

TASK	SCHEDULE																							
	JUNE 2005 – MAY 2006												JUNE 2006 – MAY 2007											
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
1. Develop QAPP		X	X	X																				
2. Identify Pollutant Loadings			X	X	X	X	X	X	X	X	X	X	X	X	X									
3. Sampling & Control Measures																								
3A. Existing BMPs					X	X					X	X	X											
3B. Staff Gages for Hydrology		X	X																					
3C. Ponds and Tributaries													X		X									
4. Estimate Pollutant Reductions								X	X					X	X									
5. Cost and Authority													X	X										
6. Outreach and Education														X	X									
7. Schedule/Milestones															X									
8. Success Indicators and Evaluation													X	X										
9. Monitoring Plan													X	X										
10. Restoration Plan														X	X	X	X							

The dry weather sampling of tributaries will provide an indication of dry weather flow volumes and rates of pollutants entering the pond. This information also builds upon the previous monitoring completed by Pennichuck and provides a solid baseline of water quality data.

In addition to the dry weather sampling, wet weather sampling of six existing BMP locations will also be performed. Both inlets and outlets of each of the six BMPs will be sampled to obtain information on the actual efficiency of the BMPs. This information will be extrapolated to the

existing BMPs throughout the watershed to determine existing reductions in pollutant loadings. The stormwater sampling standard operating procedure is included as Appendix D.

The modeling component of this QAPP will be used to accurately predict stormwater concentrations and in-pond concentrations as well as predict runoff throughout the watershed. The model that will be used is the Storm Water Management Model (SWMM) EPA Version 5.0.006 because it can simulate pollutant loadings associated with stormwater runoff and has the ability to model pollutant removals associated with Best Management Practices (BMPs) throughout the watershed. The model uses an hourly time step, which allows for calibration using individual storm data and can predict in-pond concentrations based on the calculated loadings, allowing for comparison and adjustment to real data. It can also run all subwatersheds simultaneously and can use GIS data as inputs. The model was first developed in 1971 and since then has undergone major upgrades. The model has proven successful in many cases. For more information on the SWMM model refer to User's Manual in Appendix B.

The following is a description of all of the tasks associated with the development of the watershed restoration plan and associated objectives. Refer to Table A6-1 for the project schedule.

1. Develop QAPP

A Quality Assurance Project Plan (QAPP) will be developed which will detail protocols and/or approaches for sampling and modeling. The QAPP will be developed in accordance with EPA guidelines and submitted to DES for review and editing. The QAPP will be revised in accordance with DES comments and submitted to EPA for approval. No data collection will be performed prior to QAPP approval by EPA.

2. Identify Pollutant Loadings

Phosphorus loadings into the chain pond system were estimated in the original 1998 watershed plan based on surrounding land uses. Phosphorus loadings will be updated based on more recent data, land use and using new water quality data collected in the last two years by Pennichuck. The loadings will be modeled using a Total Maximum Daily Load (TMDL) approach, since this section is listed as impaired. Modeling will be performed to calculate pollutant loadings, receiving water quality and to evaluate BMPs. Sediment loadings will also be evaluated since these carry pollutants with them and also reduce the capacity of the ponds. Existing water quality data and data collected under this project will be used to calibrate the pollutant loadings. Water quality goals will be established and the model will be used to estimate the pollutant reductions needed to achieve these goals.

3. Sampling & Control Measures

3A. Existing BMPs

Six existing BMPs will be sampled during three storm events to determine their effectiveness for use in the pollutant load reduction modeling. BMPs will be selected to represent a variety of BMP techniques that have been used and are likely to be proposed for future projects. This will allow for the use of more accurate removal rates in the model to determine pollutant loads removed from existing and future BMPs. BMPs will

be sampled for total phosphorus and for total suspended solids (TSS). Total phosphorus is being sampled since two of the ponds are listed for excess algal growth, which is typically associated with excess phosphorus in fresh water systems. TSS is being sampled since pollutants are usually attached to the sediment and it takes away from the water supply capacity. All sampling is to be performed by Pennichuck. CEI will assist Pennichuck in selecting and setting up in-line stormwater samplers. Pennichuck will collect the samples and have them analyzed through the certified laboratories presented in Appendices K & L. Refer to Map A6-1 in Appendix A for sampling locations.

3B. Staff Gages for Hydrology

Monitoring data is more meaningful in preparing loading information if it is tied into flow. Six locations will be selected and staff gages will be installed at these tributary sampling locations. A stream cross-section for each location will then be surveyed to allow for the collection of flow data during sampling rounds. CEI will set up the staff gages and survey the stream cross-sections. The stream flow calculations standard operating procedures is included as Appendix H.

3C. Ponds and Tributaries

Ponds and tributaries will be sampled to determine the existing water quality in the watershed. Seven pond locations (14 samples top and bottom) and six tributaries will be sampled for color, specific conductance, total suspended solids (TSS), total dissolved solids (TDS), turbidity, alkalinity, phosphorus, nitrate, ammonia, total Kjeldahl nitrogen (TKN), chloride, iron and manganese. The pond locations will also be sampled for dissolved oxygen (DO) and secchi disk readings. Samples will be collected twice during the summer. Pennichuck will perform all sampling activities. Refer to Map A6-2 and A6-3 in Appendix A for sampling locations.

Several control measures were identified in the previous watershed management and subwatershed non-point source evaluations to address the sources of pollution identified in these studies. Additional control measures will be developed as needed based on the outcome of Task 4 to achieve load reduction and water quality goals identified in Task 2.

4. Estimate Pollution Reductions

Load reductions expected for the management measures identified previously in the 10-year plan will be estimated. BMPs that have already been completed and/or are currently in the process of being implemented will be input into the model to determine the remaining pollutant load reductions needed to meet water quality goals. The sampling results collected under Task 3 will be used to validate/adjust the removal efficiencies of the BMPs to obtain more accurate loading reductions. This will establish a new baseline for pollutant load reductions. Pollutant reductions associated with the remaining BMPs that have been recommended, but not yet implemented, will also be input into the model to determine the total pollutant loading reductions anticipated from these measures and whether additional measures are needed to meet water quality goals. This will be completed on a subwatershed level and will help direct where additional measures are needed.

5. Costs and Authority

Cost estimates to implement the recommended control measures will be prepared. The expected sources of funds to implement the plan will also be identified, including private funds, local grant programs and in-kind services.

6. Outreach and Education

An information/education component will be incorporated into the plan. A one-day workshop for municipal officials will be used to outline the findings of the pollutant modeling and proposed control measures and to obtain input on the selection and implementation of the management measures. The use of publicly owned lands and easements will be discussed for BMP implementation. CEI will schedule the workshop, prepare materials for discussion at the workshop, and present the findings of the modeling and BMP investigations.

7. Schedule/Milestones

A schedule for implementing the NPS management measures identified in the plan will be prepared. This will include interim, measurable milestones.

8. Success Indicators and Evaluation

A set of criteria will be developed to determine whether loading reductions or habitat restoration is being achieved over time and substantial progress is being made towards attaining water quality standards. The criteria will be used to assess the success of the plan and to determine whether the plan needs to be revised to help meet water quality goals.

9. Monitoring Plan

A monitoring program will be developed to evaluate the effectiveness of the implementation efforts over time. This will be compared to the criteria established under Task 8, so that adjustments can be made as necessary.

10. Restoration Plan

The information generated in Tasks 1-9 above will be incorporated into a Draft Watershed Restoration Plan submitted to DES. The final will be published electronically. Quarterly reports on the progress of the project will be submitted to DES.

A7. Data Quality Objectives (DQOs) for Measurement Data

Wet Weather Sampling

The wet weather sampling quality objective of this QAPP is to analyze the quality of water entering and exiting the 6 existing BMPs through stormwater sampling. Data will be used to assess the effectiveness of the installed BMPs in removing phosphorus and sediment from stormwater. It will also be used to evaluate pollutants associated with stormwater from various land use types, which will assist in calibrating the model.

Dry Weather Sampling

The dry weather sampling quality objective of this QAPP is to analyze the water quality of the chain ponds and various tributaries which will help measure overall health of the watershed and ponds. This data will be used to help calibrate the model to actual conditions.

Data quality objectives for sampling methods will include precision, accuracy/bias, representativeness, comparability, and completeness:

Precision is a measure of the reproducibility of repeated measurements and will be determined by analyzing sample replicates. If sample replicates fall within a specified critical range for that parameter, the precision will be acceptable. If the replicate falls outside the critical range, the sample will be run again to determine if there was an error in the analyzer or the lab/field equipment that led to the imprecision. Lab and field duplicates will be collected once each sampling event for each parameter analyzed. Duplicates will be taken from the same aliquot. Table A7-2, Data Quality Objectives, shows the measurement precision for each parameter.

Accuracy/Bias is an indicator of measurement confidence and will be calculated based on analytical results of laboratory spiked samples of known chemical concentrations. Laboratory analysis will include the division of a sample into two aliquots with a known amount of a standard added to one aliquot. Both aliquots are then analyzed and the amount of the spiked material recovered will be compared to the amount added. Spike samples will be analyzed at a frequency of one per analytical batch. Laboratory spikes will not be performed for parameters measured during multi-meter use due to the impracticality of this analysis. Multi-meter parameters will be compared against the manufacturer's calibration solution.

Representativeness is the extent to which the sampling design and measurements obtained adequately reflect the true environmental conditions at the location being monitored. This will be evaluated based on the appropriateness of the selected sampling sites for describing specific impacts and general characteristics, the appropriateness of the sample collection points and frequency based on temporal and spatial variations, and the appropriateness of the selected parameters to the type of impact.

Comparability is the degree to which data can be compared directly to similar studies. In-situ data will be appropriately compared through the use of the same multi-meter, field protocol, locations, and frequency. Stormwater inlet and outlet samples and lake sample collection will follow this QAPP and will be in addition to previous baseline water quality for future sample collection and studies for comparison.

The historic in-pond data collected should be comparable to in-pond data collected during this study. Pennichuck staff performs all of the sampling, ensuring that the samples are collected from the same locations each time. They also receive in-house training that covers calibration and decontamination of equipment between sampling rounds and sampling locations, as is required under this QAPP. Samples are sent to certified laboratories for analysis, the same laboratories that are proposed in this QAPP. The major difference in data collection and analysis is that historically, field blanks and duplicates were not used. CEI will review all historic data for trends and to determine if there are any inconsistencies that may make the data questionable. This analysis will be performed for existing in-pond data and for historic tributary sampling locations and data.

Completeness is the percentage of validated data compared to the total amount of data collected. The data set will be considered complete when 90% of it meets the above established criteria (precision, accuracy/bias, representativeness, and comparability).

Data quality objectives and criteria are discussed in Tables A7-1 and A7-2.

Table A7-1. Data Quality Indicators

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance
Precision-Overall	RPD ≤ 25%	Field Duplicates
Precision-Lab	RPD ≤ 20%	Lab Duplicates
Accuracy/Bias	80-120% Recovery of Spikes; Max 20% RPD for duplicates	Spikes/Duplicates, commercial audit samples
Representativeness	Current field program was designed to obtain data representativeness through the screening and selection of sample locations.	Review of storm event data and drainage system characteristics.
Comparability	Similar to previous monitoring/sampling programs where applicable as well as between sites for the current project.	Data comparison and evaluation by Project Manager and Technical Advisors, as appropriate for this project.
Completeness	90% data will meet all acceptance criteria in Table 7.2.	Data Completeness Check

Table A7-2. Data Quality Objectives

Matrix	Parameter	Units	Reporting Limit	Method Detection Limit	Accuracy/Bias	Overall Precision	Measurement Range
Dry Weather In-Lake	Specific Conductance	uhmos/cm	1	NA	Recovery range is dependent on particular "Known Standard" in use	<25% RPD	1.0-10,000
Dry Weather In-Lake	Color	Color units	0	NA	NA	NA	0-200
Dry Weather In-Lake	Turbidity	NTU	0.5	NA	NA	<25% RPD	0.5-40
Dry Weather In-Lake	Alkalinity	mg/L	1.00	NA	80-120% recovery for laboratory control sample	<25% RPD	

Stormwater & Dry Weather In-Lake	Total Phosphorus	mg/L	0.010	0.005	85-115% recovery for laboratory control sample	<25% RPD	0.010-0.7
Dry Weather In-Lake	Nitrate Nitrogen	mg/L	0.1	0.006	90-110% recovery for laboratory control sample	<25% RPD	0.1-5.0
Dry Weather In-Lake	Total Kjeldahl Nitrogen (TKN)	mg/L	0.25	0.2	64-137% recovery for laboratory control sample;	<25% RPD	0.25-3.0
Dry Weather In-Lake	Ammonia Nitrogen	mg/L	0.100	0.078	60-130% recovery for laboratory control sample	<25% RPD	0.10-3.0
Stormwater & Dry Weather In-Lake	Total Suspended Solids (TSS)	mg/L	4	NA	Recovery range is dependent on particular "Known Standard" in use	<25% RPD	0-400
Dry Weather In-Lake	Total Dissolved Solids (TDS)	mg/L	10	NA	Recovery range is dependent on particular "Known Standard" in use	<25% RPD	0-5,000
Dry Weather In-Lake	Chloride	mg/L	1.00	0.04	90-110% recovery for laboratory control sample	<25% RPD	1.00-5.00
Dry Weather In-Lake	Iron	mg/L	0.050	0.04	85-115% recovery for laboratory control sample	<25% RPD	0.050-10.0
Dry Weather In-Lake	Manganese	mg/L	0.010	0.01	85-115% recovery for laboratory control sample	<25% RPD	0.01-10.0
Dry Weather In-Lake	Total Organic Carbon (TOC)	mg/L	0.5	0.1	80-120% recovery for laboratory control sample	<25% RPD	
Dry Weather In-Lake	DO	mg/L	NA	<0.5	± 0.2	± 0.1	0-12
Dry Weather In-Lake	Temperature	°C	NA	NA	± 1.0	± 0.3	0-32
Dry Weather In-Lake	PH	pH units (standard units)	NA	NA	± 0.1 of QC Standard	± 0.05	4.0-10.0
Dry Weather In-Lake	Secchi Disk Transparency	M	0.2	NA	NA	± 0.2m for duplicate readings by same monitor as well as different monitor	0.0-10.0

NA = Not Applicable

Modeling

The modeling objective of the QAPP is to accurately predict stormwater concentrations and in-pond concentrations as well as runoff throughout the watershed. The wet weather data will be used to calibrate the literature based land use coefficients initially used to estimate pollutant loadings and will also be used to determine the removal efficiency of various BMPs throughout the watershed. This information will be used in the model to more realistically represent actual conditions. The dry weather sampling will also be used to calibrate the model, as it represents

average pollutant concentrations and loadings over time and can be used to calculate baseflow loadings. Land use based loadings will be adjusted to more closely match estimated in-pond concentration based on loadings to actual in-pond concentrations. The users' manual for the SWMM Model is included in Appendix B.

Acceptance criteria for intended use of existing data

Existing sampling data will be used as input to the modeling effort. There is only limited existing sampling data available for model calibration. As more data is collected this fall and early next year, it will be used to calibrate the model. This data will include wet weather sampling and flow data, dry weather sampling and flow data, BMP & land use sampling and flow data, and in-pond sampling. The model will be calibrated to minimize the difference between the observed values and the predicted results from the model. As more data is available, it will be possible to better calibrate the model. Existing data will be judged acceptable for their intended use if they are deemed reasonable compared to the entire data set and no sampling errors are perceived.

Table A7-3. Existing Data Sources & Limitations

Data Source	Data Type	Limitations
Pennichuck	Tributary & in-pond dry/wet weather sampling	No flow data, or level readings; No field blanks or duplicates.
Nashua Regional Planning Commission	Tributary dry/wet weather sampling	No flow data, or level readings; No field blanks or duplicates

Acceptance criteria for model calibration

Element B7 discusses the approach to be taken to calibrate the SWMM model. CEI is defining model calibration in this setting as how well the model is able to reproduce current observed concentrations of in-pond phosphorus values as measured by Pennichuck sampling data. The model will be calibrated to ensure a coefficient of determination (R^2) of at least 0.75 for the sampling data used for calibration excluding any outliers.

A8. Training Requirements / Certification

Wet and Dry Weather Sampling

This investigation includes no non-routine field sampling techniques, field analyses, laboratory analyses, or data validation. Specialized training is therefore not required, however; all field personnel are experienced in standard protocols for sampling water using the equipment identified within this QAPP. All staff members receive sample collection training by the Pennichuck lab manager. Certifications relevant to implementation of this plan are not required.

Modeling

No special training is required for the pollutant modeling work. CEI is experienced with various pollutant loading and receiving water models and will use this experience in this project.

A9. Documentation and Records

Wet and Dry Weather Sampling

Documentation accompanying samples from field collection and monitoring through laboratory analysis include field data sheets, sample labeling, chain of custody forms and lab data sheets.

Field Data Sheets will be completed on-site at the time of sampling and monitoring and will be provided to each field team. Field sheets will include the following information:

- Site name and location
- Names of field team personnel
- Weather conditions
- Site observations
- Name of sample collected
- Sample identification
- Location of sample
- Date of collection
- Time of collection

Sample Labeling will include a label for each sample bottle collected in the field and filled out with an indelible writing instrument. The label will include the following information.

- Name of sample collected
- Sample identification
- Location of sample
- Date of collection
- Time of collection
- Initials of person collecting the sample
- Preservative
- Analysis

A Chain of Custody will be used to track the samples from the collection point through analysis and data management. Chain of Custody records will be signed by the sampler before samples are relinquished to appropriate laboratories. The records will also be signed by the receiving laboratory. The Field Team Leader and the laboratory analyzing the sample will maintain copies of the Chain of Custody. Appendix C contains the appropriate sample Chain of Custody forms.

The Chain of Custody will contain the following information:

- General project information
- Sample identification
- Date of collection
- Time of collection
- Sample matrix
- Sample analysis
- Additional comments as appropriate

Lab Data Sheets will be used by the participating laboratories to document sample processing and analysis. Lab data sheets will be kept for each parameter analyzed and will include: name of

lab, analysis date, time of sample arrival at lab, time samples were analyzed, sample ID # and site #, raw results, calculated results, name of lab analyst, and internal QC procedures. Original lab data sheets will be maintained in a central lab archival location for several years.

Modeling

Historical Data and Information used in the modeling effort will include previous water quality sampling data that will be used in the calibration process. This data includes:

Table A9-1. Historical Tributary and In-Pond Data

Sample Location and Quantity	Date of Sampling Data
6 Tributary Sampling Locations (Pennichuck)	7/7/04
6 In-Pond Sampling (Pennichuck)	8/26/99, 9/14/99, 9/28/99, 7/23/03, 10/28/03, 6/30/04, 8/26/04, 6/23/05, 8/4/05, 9/8/05
13 Tributary and In-Pond Sampling Locations (Pennichuck)	7/17/96, 8/28/96, 12/5/96
11 Tributary and In-Pond Sampling Locations (Pennichuck)	11/14/95, 11/15/95, 4/17/96, 5/1/96, 5/2/96, 5/15/96, 5/30/96, 6/13/96, 6/26/96, 7/9/96
8 Tributary Sampling Locations (NRPC)	6/21/05, 7/5/05, 7/19/05, 8/2/05, 8/16/05, 9/1/05, 9/13/05, 9/26/05

GIS Information will be used to develop land use maps for modeling purposes. This information will be obtained through GRANIT and through the Nashua Regional Planning Commission (NRPC) and will be added to throughout the modeling process.

Modeling Parameters such as pollutant build up rates, washoff coefficients, land uses, BMP removal efficiencies, proximity to and contribution of septic systems, atmospheric loadings, weather data and pond characteristics will be documented. Typical pollutant apparent settling velocities will be used for the in-lake modeling component. The final report will include these parameters and documentation of the calibration process, including which parameters were adjusted and by how much to match field observed conditions.

Data Storage

Pennichuck will maintain original field data sheets, laboratory data sheets, and Chain of Custody forms. Hard copies of the original documents will be provided to NH DES and Comprehensive Environmental Inc. (CEI) for inclusion in the sampling results letter report. Electronic files associated with the sampling results letter report will be stored with Pennichuck and CEI for distribution. Both Pennichuck and CEI servers are backed up weekly by the respective office manager. Once projects are inactive, electronic data is archived onto another server.

B1. Sampling Process Design

Sample Site Selection

Wet Weather Sampling

Wet weather sampling and monitoring will be performed at the inlets and outlets to six BMPs throughout the watershed. The BMPs to be sampled were chosen to represent a variety of

techniques that have been used and are likely to be proposed for future projects. As discussed in the stormwater SOP (Appendix D), inlet and outlet samples will be collected to determine the amount of Total Phosphorus (TP) and Total Suspended Solids (TSS) coming to and removed by each BMP sampled. As discussed previously, TP and TSS have been identified as target pollutants for BMP removal.

Dry Weather Sampling

Dry weather sampling and monitoring will be performed at seven pond locations and nine tributaries. The pond sample sites are marked with buoys at the deepest parts of the ponds and were chosen to evaluate the effects of stratification on water quality and the overall health of the ponds. This information is useful in calibrating the model, as it provides real concentrations in the pond. The tributary sites were chosen to represent the overall health of the watershed and to determine which areas require more attention than others. NRPC recently sampled many of these locations, which will also be used in calibrating the model.

Modeling

The combined sampling locations, from this study and the NRPC project will provide pollutant information for areas throughout the watershed, which will be useful for modeling various areas and comparing model results with actual concentrations.

Sample Collection

Wet Weather Sampling

Wet weather sample collection procedures are outlined in the Standard Operating Procedures located in Appendix D.

Three rounds of stormwater samples will be collected during first flush conditions (when pollutant concentration is greatest). The timing of sample collection is based on the "time of concentration" or travel time of runoff for each sample location drainage area. Time of concentration represents the time it takes runoff from the outermost point in a drainage area to reach the lowest point in the drainage area. Thus, pollutants from the upper reaches of the drainage area will reach the inlet at this time, resulting in greater pollutant concentrations during the first flush. Time of concentration was calculated based on urban runoff (less forested areas) travel times to each sample location using the Virginia Tech/ Penn State Urban Hydrology Model (VT/PSUHM). Sample location calculations and a methodology description for VT/PSUHM are provided in Appendix F.

The samples will be collected using a SS201 Stormwater Sampler, which will be scheduled to collect a discrete sample after the time of concentration has elapsed. The samplers will be installed in an upstream manhole or at the outfall discharging into the BMP. The outlet sampler will be installed at the discharge of the outlet structure. The instruction manual for the SS201 Stormwater Sampler is included in Appendix G. Pennichuck staff will go out after the storm events to collect the samples and send them to the lab to be analyzed. Duplicates will be split from the original sample container.

All sites will be sampled as described above except for the Pennichuck Square site where infiltration is the primary treatment component. Therefore this site will require an additional measure to estimate the BMP removal efficiency. A sampler and water level logger will be

installed in the catch basin in front of Pennichuck Square which has the largest drainage area. The pollutant concentration and runoff volume will be extrapolated for the entire site from this catch basin. A sampler and water level logger will be installed at the outlet of the last manhole before the stormwater is discharged to the brook. These two components represent the pollutants and water volumes entering the site and leaving the site untreated. To determine a BMP removal efficiency, runoff removal rates of 95% to 99% for TSS and 65% to 75% for Phosphorus will be used to calculate the treatment obtained from infiltration[1]. The overall efficiency will be calculated as a flow-weighted composite of this treated water and the untreated water leaving the site.

In addition to the sampler, a WL 15X Water Level Logger will be used to record the level in the pipes or streams, these will record a continuous level, which will be used to calculate stream flow. The manual for the WL 15X Water Level Logger is included in Appendix G.

[1] Pollutant removal efficiencies for infiltration adapted from Section 6.3 Infiltration BMPS, Stormwater Management for Maine: BMPS.

Table B1-1. Sampling/Monitoring Design – Wet Weather Data Collection

Measure(s) or Indicator(s)	Sites*	Sample Collection Time	Type of BMP and Upstream Land Use	Time of Day Sampled	Frequency & Special Weather Conditions
Total Phosphorus & Total Suspended Solids (TSS)	1. Greenleaf St, (near Home Depot)	Set samplers to collect samples 30.17 minutes after flow is detected.	Wet Pond, Low Density Residential	Since automated samplers are being used to collect the samples, sample collection will be 24 hours a day, 7 days a week. Samples will be collected and put into containers with preservative if necessary within 24 hours of sample collection. Weekend lab coordination is not necessary since samples have a holding time of 7 days (TSS) and 28 days (TP).	Three storm events with no rain 72 hrs prior to sampling. Samples must represent first flush conditions. Sampling can be conducted for storm events that generate >0.5" of precipitation in a 24-hr period. Weather reporting will be obtained from the NOAA: National Weather Service website.
	2. Home Depot	Set samplers to collect samples 30.21 minutes after flow is detected.	Grass Detention Basin, Commercial		
	3. Pennichuck Square	Set samplers to collect samples 0.74 minutes after flow is detected.	Infiltration – LID, Commercial		
	4. Celina Ave Forebay	Set samplers to collect samples 14.78 minutes after flow is detected.	Swale/Forebay, Commercial		
	5. White Oak Drive (Near Thornton)	Set samplers to collect samples 21.48 minutes after flow is detected.	Detention Basin w/ wetland Plants, Residential		
	6. White Oak Drive (off Tinker Rd)	Set samplers to collect samples 21.15 minutes after flow is detected.	Dry Naturalizing Detention Basin, Residential		

*See Map A6-1 in Appendix A for sampling locations.

Dry Weather Sample Collection

Dry weather samples will occur at in-pond and tributary locations twice during the summer months. Dry weather sample collection procedures are outlined in the Standard Operating Procedures located in Appendix E.

In addition to dry weather samples at the tributary locations, the stream flow will be measured using a staff gage installed by CEI. The SOP for Stream Flow Calculations used at tributary sample locations can be found in Appendix H.

One duplicate sample will be taken each sampling date to demonstrate the consistency of the sampling techniques. This sample will be processed in the same manner as all other samples of the same type, and the two sets of data for that time and location will be compared to determine how precise the results are.

Table B1-2. Sampling/Monitoring Design – Dry Weather Data Collection

Site ID	Parameters Measured in Field	Laboratory Samples	Number of times Sampled	Type of Sample Collected	Time of Day Sampled	Special Weather Conditions
In Pond	DO, Temp, Secchi Disk	Color, Specific Conductance, TSS, TDS, Turbidity, Alkalinity, Phosphorus, Nitrogen, TKN, Ammonia, Chloride, Iron, Manganese, TOC	Twice June through September	Grab Sample / Multiple Depths	Sample collection will be during daylight hours generally between 7 AM and 5 PM, 7 days a week	Dry Weather
Tributary	None		Twice June through September	Grab Sample		Dry Weather

B2. Sampling Method Requirements

Sample collection methods are summarized in the following tables. Detailed Standard Operating Procedures (SOP) for wet and dry weather sample collection are provided in Appendices D and E, respectively. The QA/QC officer will provide additional guidance when necessary.

Table B2-1. Container, Sample Size, Type, Preservation and Storage for Wet and Dry Weather Sampling

Indicator	Container Type	Minimum Sample Quantity (ml)	Sample Type	Preservation*	Maximum Holding Time
Color	Plastic	100	Grab	Unpreserved, cool 4°C	48 hours
Specific Conductance	Plastic	100	Grab	Unpreserved, cool 4°C	28 days
Total Suspended Solids (TSS)	Plastic	200	Grab	Unpreserved, cool 4°C	7 days
Total Dissolved Solids (TDS)	Plastic	200	Grab	Unpreserved, cool 4°C	7 days
Turbidity	Plastic	50	Grab	Unpreserved, cool 4°C	28 days
Alkalinity	Plastic	200	Grab	Unpreserved, cool 4°C	14 days
Total Phosphorus	Plastic	100	Grab	Sulfuric Acid to pH <2, cool 4°C	28 days
Nitrate Nitrogen	Plastic	100	Grab	Unpreserved, cool 4°C	48 hours
Total Kjeldahl Nitrogen (TKN)	Plastic	500	Grab	Sulfuric Acid to pH <2, cool 4°C	28 days
Ammonia	Plastic	500	Grab	Sulfuric Acid to pH <2, cool 4°C	28 days
Chloride	Plastic	100	Grab	Unpreserved	28 days
Iron	Plastic	200	Grab	Nitric Acid	6 months

Indicator	Container Type	Minimum Sample Quantity (ml)	Sample Type	Preservation*	Maximum Holding Time
Manganese	Plastic	200	Grab	Nitric Acid	6 months
Total Organic Carbon (TOC)	Darkened glass	100	Grab	Sulfuric Acid to pH <2, cool 4°C	28 days

* All samples initially stored in cooler and chilled to 4° C, all sample bottles will be pre-preserved by the analyzing laboratory as applicable prior to the sampling event.

Wet Weather Sample Methods

The wet weather samples will be collected using the SS201 Stormwater Sampler that will be scheduled to collect the sample after the first flush. Pennichuck will then transfer the collected sample to the appropriate containers as outlined in Table B2-1 within 24 hours of the storm event. Personnel will adhere to the equipment decontamination procedures described in the SOP. Refer to Appendix D for sampling SOP.

Dry Weather Sample Methods

The dry weather in-pond samples will be collected on a boat with the Wildco Depth Water Sampler that will be lowered to the appropriate level as described in Section A6 to take the samples. On-Site monitoring methods and equipment are described in table B2-2. The tributary samples will be collected directly into sample bottle, unless the bottle has a preservative in it, then it will be collected in a clean bottle and transferred into the sampling bottle. For sample locations where samples are collected from a bridge, the Wildco Depth Water Sampler will also be used. Personnel will adhere to the equipment decontamination procedures described in the SOP. Refer to Appendix E for sampling SOP.

Table B2-2. In-Situ Monitoring Methods – Dry Weather

Indicator	What Will Be Monitored	Monitoring Equipment	Monitoring Method
Dissolved Oxygen	Pond Water	YSI 55 D.O Meter	Multi-Meter is turned on and lowered to appropriate depth; unit is held at this depth until a stable reading is recorded.
Temperature	Pond Water	YSI 55 D.O Meter	Multi-Meter is turned on and lowered to appropriate depth; unit is held at this depth until a stable reading is recorded.
Transparency	Pond Water	Secchi Disk	Secchi disk is lowered from side of boat until it disappears from view. Disk is slightly raised and lowered until the point at which it just disappears and reappears is determined and recorded.

B3. Sample Handling and Custody Requirements

Wet and Dry Weather Sampling

The five steps to sample handling and custody for this project are described below.

Completion of Field Data Sheets

Field data sheets will be completed at the sample site during sampling activities and will include the following general information: site name and location, names of field team personnel, sample date/time collection, weather conditions, and site observations. Site observations will include qualitative observations (e.g., murky, milky, floatables, sheen, sewer or fishy odor) of the stormwater flow and the sample that was collected. The field data sheets will contain all information described in Appendices D and E, Stormwater Sampling SOP and Dry Weather Sampling/Monitoring SOP respectively and are included at the end of each appendix.

Sample Labeling

Sample labels will be placed on dry bottles in advance of sampling activities. Each sample label will contain the following information once sampling is complete: sample ID# (e.g., SW-1), sample type (stormwater), date and time, preservation (e.g., sulfuric acid, none), the sampler's name, and the analysis (e.g., total phosphorous).

Sample Transport and Chain of Custody

Samples will be transported to Chemserve subsequent to sample collection and within the sample holding times by a laboratory courier.

A chain of custody will be used to track the samples from the collection point through analysis and data management. The sampler will sign Chain of Custody records before samples are relinquished to the laboratory. The receiving laboratory will also sign the records. Pennichuck and the laboratory analyzing the sample will maintain copies of the Chain of Custody. Appendix C contains the sample Chain of Custody forms for participating laboratories. The Chain of Custody will contain the following information: general project information, sample identification, date of collection, time of collection, sample matrix, sample analysis, and additional comments as appropriate.

Sample Disposal

The samples analyzed in the laboratory will be disposed in accordance with New Hampshire and Massachusetts Law and the Standard Operating Procedures (SOP) of the associated laboratory.

Sample Storage

Samples will be temporarily stored by the laboratory for 14 days. This will allow for re-analysis if the initial sampling results reveal this to be necessary.

B4. Analytical Methods Requirements

Wet and Dry Weather Sampling

The following is a summary table of sample analytical methods. The laboratory turn-around time will be the standard ten days for all parameters except Total Organic Carbon which will be five days. The project manager is responsible for non-standard situations and methods.

Table B4-1. Sample Methods

Indicator	Laboratory	Method Number	Source	Reporting Units	Modifications or options
Color	ChemServe	EPA 110.2	EPA 110.2	Color units	None
Specific Conductance	ChemServe	EPA 120.1	SM – 18th ed., 2510	µS	None
Total Suspended Solids (TSS)	ChemServe	EPA 160.2	SM – 18th ed., 2540D	mg/L	None
Total Dissolved Solids (TDS)	ChemServe	EPA 160.2	SM – 18th ed., 2540C	mg/L	None
Turbidity	ChemServe	EPA 180.1	SM – 18th ed., 2130B	mg/L	None
Alkalinity	ChemServe	EPA 310.1	SM – 18th ed., 2320B	mg/L	None
Total Phosphorus	ChemServe	EPA 365.2	EPA 365.2	mg/L	None
Nitrate Nitrogen	ChemServe	EPA 300.0	EPA 300.0	mg/L	None
Total Kjeldahl Nitrogen (TKN)	ChemServe	EPA 351.3/1	SM – 18th ed., 4500 NH_{org}	mg/L	None
Ammonia	ChemServe	EPA 350.2	SM – 18th ed., 4500-NH_3F	mg/L	None
Chloride	ChemServe	EPA 300..0	EPA 300.0	mg/L	None
Iron	ChemServe	EPA 200.7	EPA 200.7	mg/L	None
Manganese	ChemServe	EPA 200.7	EPA 200.7	mg/L	None
Total Organic Carbon (TOC)	Rhode Island Analytical	EPA 415.1	EPA 415.1	mg/L	None

B5. Quality Control Requirements

Dry and Wet Weather Sampling

Table B5-1. Quality Control Checks – Wet and Dry Weather Sampling[1]

Indicator(s)[2]	Field Quality Control Checks	Accuracy Checks	Precision Checks	% Quality Control Samples
Color	Sampler is clean, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank
Specific Conductance	Sampler is clean, sample container has orthophosphorus preservative, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank
Total Suspended Solids (TSS)	Sampler is clean, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling– both dry and wet weather); lab blank
Total Dissolved Solids (TDS)	Sampler is clean, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank
Turbidity	Sampler is clean, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank
Alkalinity	Sampler is clean, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank
Total Phosphorus	Sampler is clean, sample is transferred immediately from sampler to sample container, sample container has sulfuric acid preservative, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling– both dry and wet weather); lab blank
Nitrate Nitrogen	Sampler is clean, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank

Total Kjeldahl Nitrogen (TKN)	Sampler is clean, sample container has sulfuric acid preservative, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank
Ammonia	Sampler is clean, sample container has sulfuric acid preservative, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank
Chloride	Sampler is clean, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank
Iron	Sampler is clean, sample container has nitric acid preservative, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank
Manganese	Sampler is clean, sample container has nitric acid preservative, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank
Total Organic Carbon (TOC)	Sampler is clean, sample container has sulfuric acid preservative, sample is transferred immediately from sampler to sample container, container is properly sealed and immediately placed on ice.	Use commercial audit samples Spiked sample recovery	Field and lab replicate analysis	10% (1 field duplicate is collected per sampling); lab blank

1. The QA/QC Officer will evaluate the field and lab data when available to determine if the QC samples reveal any sampling or analytical problems.
2. Quality control protocols and SOPs for participating laboratories are provided in Appendix J and K.

Table B5-2. Quality Control Checks – In-Situ Monitoring

Indicator(s)	Field Quality Control Checks	Accuracy Checks	Precision Checks	% Quality Control Samples
Dissolved Oxygen	Instrument is clean.	Calibration check of unit prior to sampling event.	Field replicates by observer.	10%
Temperature	Instrument is clean.	Calibration check of unit prior to sampling event.	Field replicates by observer.	10%
Transparency	Secchi disk is clean and calibrated line is readable.	Calibration check of calibrated line prior to sampling event.	Field replicates by observer.	10%

B6. Instrument/Equipment Testing, Inspection, and Maintenance

Table B6-1. Field Equipment Inspection and Maintenance.

Equipment Type	Inspection Frequency	Type of Inspection	Available Parts[1]	Maintenance, Corrective Action & Recordkeeping
Secchi Disk and Calibrated Line	Prior to each sampling event	Disk is clean and line is readable	Spare disk and line	Annually or as needed Logbook notation
YSI 55 D.O Meter	Prior to each sampling event	Battery life is appropriate for monitoring time, electrical connections are in check, membranes are functioning	Spare batteries and membranes	Annually or as needed Logbook notation
Hanna pH Meter	Prior to each sampling event	Battery is ok, sensor is ok	None	Annually or as needed Logbook notation
Wildco Depth Sampler	Prior to each sampling event	Instrument is clean; extension mechanism is working correctly	Spare sampler	Logbook notation

[1]Spare parts are located in the lab storage room down the hall from the lab in the Water Treatment Plant.

Table B6-2. Laboratory Equipment Inspection and Maintenance.

Equipment Type	Inspection Frequency	Type of Inspection	Available Parts[1]	Maintenance, Corrective Action & Recordkeeping
Filtration Apparatus	Before each analysis	Cleanness and completeness of equipment, sufficient filters	Extra filters and hand pumps	Annually or as needed Logbook notation
Lab Benches	Before each analysis	Cleanliness, chips, cracks	Patch or filler kit	Clean and disinfect before each analysis date
Spectrophotometer	Before each analysis	Proper operation, cleanliness	According to manufacturers directions	Annually or as needed Logbook notation Semi-annually
Analytical Balance	Each day of use	Cleanliness, Check alignment	Per manufacturer	Semi-annually or as needed Logbook notation

[1]Spare parts are located in the lab storage room down the hall from the lab in the Water Treatment Plant.

B7. Instrument/Equipment Calibration and Frequency

Wet and Dry Weather Sampling

The following tables outline field and laboratory calibration procedures. Detailed calibration procedures for the YSI 55 D.O. Meter and the Hanna pH meter are included in Appendix I. Instrument calibration procedures and SOPs for participating laboratories are included in Appendices K and L.

Table B7-1. Field Instrument Calibration Procedures

Equipment Type	Inspection and Calibration Frequency	Standard of Calibration Instrument Used	Logbook Notation	Corrective Action
Secchi Disk and Calibrated Line	Daily and checked at end of day.	Tape measure	Yes	Recalibrate or replace with calibrated line
YSI 55 D.O. Meter	Daily and checked at end of day.	Following manufacturers instructions	Yes	Replace membrane or adjust instrument
Hanna pH Meter	Daily and checked at end of day.	Following manufacturers instructions	Yes	Recalibrate or repair if necessary

Table B7-2. Laboratory Calibration Procedures

Equipment Type	Inspection and Calibration Frequency	Standard of Calibration Instrument Used	Logbook Notation	Corrective Action
Spectrophotometer	Prior to use	Manufacturers' standards	Yes	Replace/calibrate
Analytical Balance	Prior to use	Manufacturers' standards	Yes	Replace/calibrate
Ion Chromatograph	Prior to use	Manufacturers' standards	Yes	Replace/calibrate
Conductivity Meter	Prior to use	Manufacturers' standards	Yes	Replace/calibrate
PH Electrometer	Prior to use	Manufacturers' standards	Yes	Replace/calibrate

Modeling

The model that will be used is the Storm Water Management Model (SWMM) EPA Version 5.0.006 (9/5/05) because it can simulate pollutant loadings associated with stormwater runoff and has the ability to model pollutant removals associated with Best Management Practices (BMPs) throughout the watershed. This model version was produced by the Water Supply and Water Resources Division of the US EPA in conjunction with CDM, Inc. The SWMM model will be developed using GIS input data and typical pollutant parameters. This model was selected because it is very versatile and as more data is collected, it can be updated in the future to more accurately predict watershed responses to rainfall. The SWMM model will be calibrated using

existing and proposed sampling data collected during wet and dry weather sampling events. A limitation of the model is that due to inadequate data, it cannot accurately predict stream baseflow. The dry weather tributary flows will be used to calculate the baseflow and background pollutant levels to input into the SWMM model. Stormwater outfall and stream flow sampling will be compared directly against model outputs. This wet weather sampling data will be used to calibrate SWMM stormwater pollutant loadings from specific land-uses and subwatersheds. The model results will be input into the lake model, which will be used to estimate in-pond phosphorus concentrations. This model will use an apparent settling velocity to predict the in-pond concentration from input concentrations. In addition, bathymetric data will be used to model in-pond concentrations. This will be compared against the water quality samples taken by Pennichuck. Pollutant loading and washoff parameters will be adjusted to predict in-pond concentrations similar to actual observed concentrations. Calibration will be complete when the model reasonably predicts the observed phosphorus and TSS concentrations.

If problems are encountered during the modeling, the project engineer/technical advisor will be notified if the problem is associated with the data used and difficulties getting the model to calibrate to this data. If problems are associated with running the model itself (i.e., software errors), the software manufacturers technical support groups will be contacted to work through these problems.

The input data for the SWMM calibration will come from historical, recent and proposed sampling data from the NRPC and Pennichuck Water Works.

B8. Inspection/Acceptance Requirements for Supplies

Wet and Dry Weather Sampling

Inspection of supplies will be performed by Pennichuck personnel conducting the sampling.

Table B8-1. Recommended Inspection for Supplies.

Supplies	Inspection Frequency	Type of Inspection	Available Parts	Maintenance
Field and Lab sample sheets	Before each sampling event	Visual	Additional copies	None necessary
Life Preservers	Before each sampling event	Visual inspection for damage	Patch kit	As needed
Sample Bottles	Before each sampling event	Integrity, cleanness and seal for nutrient bottles	One set of spare bottles	None necessary
Extended Stormwater Sampler	Before each sampling event	Integrity and cleanliness	Spare sampler	Clean prior to each sampling event
Cooler	Before each sampling event	Cleanness, Ice packs	None necessary	Annually or as needed

B9. Non-direct Measurements

Dry and Wet Weather Sampling

Maps will be prepared using GRANIT, CEI, and NRPC data layers to identify monitoring locations and the general land features in the area. Rainfall information for each sampling date will be obtained from the NOAA National Weather Service website and used for data evaluation at the completion of sampling events. A potential limitation of the data is that it may not represent this watershed specifically. Weather data will be obtained from the closest weather station, which should be adequate for evaluation of samples and modeling. Dry weather sampling of tributaries and ponds previously collected by Pennichuck and NRPC will be used in conjunction with the newly collected data to develop a baseline of water quality data throughout the watershed. Pennichuck has been using the same laboratory and procedures in collecting historical data as proposed for this project. Therefore it is assumed that the historical data meets all the QC requirements.

Modeling

GIS data layers from GRANIT, CEI and NRPC including watershed boundary, land use, soil type, hydrology, roads, drainage layers, USGS Topographic map and orthophotos will also be used in conjunction with the model. Data collected during this project will be used to determine effectiveness of BMP designs, prioritize sites for future BMP implementation and used for comparison with future water quality monitoring efforts. Potential limitations of this data are that it is often based on regional information, so may not be 100% accurate for the area we are dealing with. However, we believe it to be adequate for modeling the Pennichuck Water Works pond system.

B10. Data Management

Wet and Dry Weather Sampling

The field and laboratory data collected during this project will be managed according to the following stages:

Raw Data

Field and lab data sheets will be signed and checked for completeness by the Laboratory QA Officer. Any omissions or apparent errors will be verified with the field samplers. Chain of Custody forms will follow the samples and the Laboratory QA Officer will inspect data sheets as soon as they are received. If any problem is suspected at this time, samplers will be contacted. Lab analysts will flag data and comment on any samples that did not arrive at the required temperature according to the SOP. Data sheets and Chain of Custody forms will be sent to the Project Manager and QA/QC Officer as soon as the results are in.

Data Entry and Validation

The field and laboratory data will be entered into a spreadsheet (MS Excel). Final results may be displayed using ArcView maps, if appropriate. The tabulated data will be checked against the field and lab sheets to assure that all data has been entered correctly. The data will be critically

reviewed by the Project Manager & QA/QC Officer for reasonableness, correspondence with data quality objectives, and appropriate qualification or censoring of suspect data.

Data Storage

Pennichuck will maintain original field data sheets, laboratory data sheets, and Chain of Custody forms. Hard copies of the original documents will be provided to NH DES and Comprehensive Environmental Inc. (CEI) for inclusion in the sampling results letter report. Electronic files associated with the sampling results letter report will be stored with Pennichuck and CEI for distribution.

Modeling

Data collected and used in the modeling process will be documented in the final Watershed Restoration Plan report.

C1. Assessment and Response Actions

Wet and Dry Weather Sampling

The Project Manager will observe the people collecting the samples to assess their understanding of the written procedures at the beginning and end of the first dry weather of sampling round and at the beginning and end of the first wet weather sampling round. If any deviations from the procedures are observed, they will be corrected. The QA/QC Officer will be responsible for overseeing data collection activities and handling corrective actions that pertain to data collection and data entry. The QA/QC Officer will inform the Project Manager with the results of corrective actions. The Project Manager and QA/QC Officer will be responsible for oversight and follow-up on corrective actions. The Project Manager and QA/QC Officer will also be responsible for reviewing the field data sheets and tabulated laboratory data for information that pertains to data quality objectives. The Technical Advisors will assist the Project Manager & QA/QC Officer with these tasks, as appropriate. The participating laboratories will also provide the laboratory assessment procedures.

Modeling

Calibrating the Model - The model calibration procedure is discussed in Element B7, and criteria for acceptable outcomes are provided in Element A7. During calibration the calibrated parameters will consistently be compared to typical values to ensure they are realistic for the respective pollutant or landuse. If the parameter is outside of this range, the model will be recalibrated.

Sensitivity Analyses – A sensitivity analyses will be performed by CEI on the model parameters for various situations. Each calibration parameter will be analyzed to identify its influence on the overall model. Parameters with the greatest influence on the model will be modified carefully to prevent model calibration from creating unrealistic parameters. The parameters that the model is most sensitive to will be noted.

C2. Reports to Management

A summary memo will be prepared after the completion of each sampling event, once data results are received but at a minimum at least prior to the next sampling event. The memo, prepared by the Project Manager with input from the QA/QC Officer, will summarize the sampling/monitoring event and note any problems that occurred with recommendations for improvement prior to the next sampling event. Memos will be distributed to the following parties electronically for comment and information purposes: CEI and NH DES. An additional summary report will be completed after the loading modeling has been run.

The status of the project, including the sampling program, will be outlined in quarterly reports submitted to DES.

Final sampling/monitoring results will be incorporated into the final project report required by the DES s.319 Grant Program at the completion of the project.

The project manager along with assistance from CEI will be responsible for this final report. Draft copies will be distributed to the above parties for review and comment prior to finalization.

D1. Data Review, Validation, and Verification

Sampling

All data will be reviewed by the Project Manager and QA/QC Officer as well as the DES Project Officer to determine if they meet the QAPP objectives as discussed in Section A7. The sampler will initially review field data for completeness as soon as possible after collection. If data review indicates a problem with a particular sample, it is possible that another sample round will be collected at the site. The Project Manager and QA/QC Officer will determine the appropriateness and need for such an action.

Appendix F includes the time of concentration calculations which will be used to program the automated samplers for collecting samples in the 6 existing BMPs.

The Project Manager and QA/QC Officer will review laboratory data for completeness as soon as possible after analysis. Data on field duplicates, lab duplicates, and other quality control measures should accompany the sample data. If discrepancies that exceed the data quality objectives are observed, re-analysis may be possible, as long as additional sample material is available and holding times have not been exceeded.

The Project Manager and QA/QC Officer using all available QC data will review the combined data set after the field collection data. Deviations will be flagged, incomplete data will be noted, and sampling staff and volunteers will be reminded that complete data logs are necessary. Calculations will be spot-checked. QC results that deviate from the data quality objectives will call the validity of the individual data or all related data into question. The final decision on whether to include or reject the data will be made by the Project Manager and QA/QC Officer and the DES Project Officer.

Modeling

The modeling results will be reviewed by the Project Manager, Project Engineer and QA/QC Officer for completeness and reasonableness. The predicted in-pond concentrations from the

model will be compared to the observed concentrations from sampling events to validate the model. See Appendix F for in-pond calculation methodology.

D2. Validation and Verification Methods

Wet and Dry Weather Sampling

Each verifying group will examine all data for logical consistency, as presented in Table D2-1. If inconsistencies are found, an attempt will be made to determine whether the data is in error. For example, field notes taken at the time of the sampling event might indicate possible reasons for any inconsistency. Any apparent problems will be noted in the final reports as appropriate.

Table D2-1. Validation and Verification Procedures

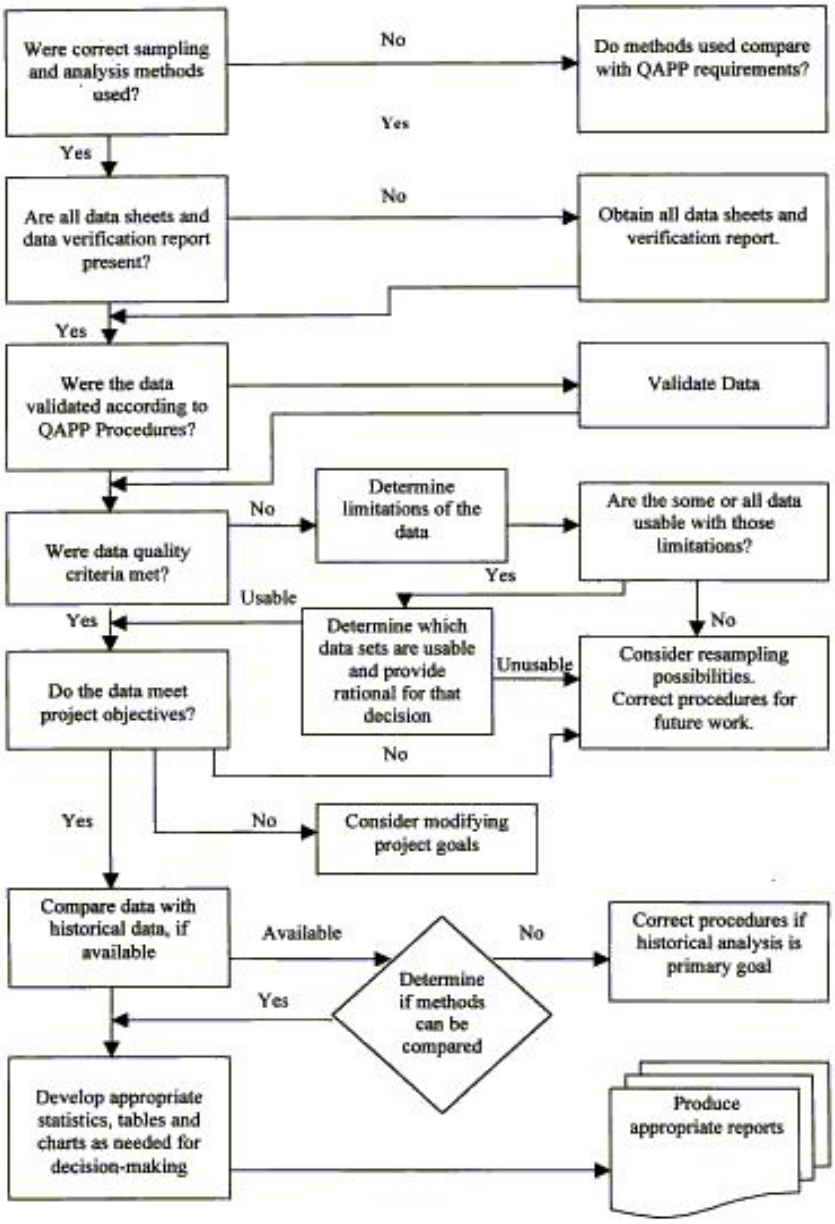
Verifying Group	When	Activity	Possible Corrective Measures and Notification
Sampler	Sampling day – when samplers turn in their data sheets, chains of custody	Collect, review volunteers' field sheets for outliers, illegible data entries, missing data, etc.	Discuss with other samplers. Flag problems that are not correctable. Fill in missing data.
Laboratory QA Officer	Sampling day – when samples are submitted, chains of custody	Same as above for chain of custody. Check for samples that exceeded holding time, arrived in improper condition (i.e., too warm, improperly sealed).	Discuss with Project Manager and fix correctable errors. Re-analyze if possible and flag any problems that are not correctable.
QA/QC Officer	At end of sample/ analysis day	Review data/ observation and chain of custody sheets.	Discuss any outliers or errors with other team members and correct those found.
Project Manager / QA/QC Officer	Shortly after each sampling date, when data compilation has been completed and when QC data are reported. New data summaries.	Compare # of QC tests performed vs. # outlined in QAPP. Compare QC test results with targets or expected values. Spot-check calculations. Check for transcription errors. Check again for outliers. Compare commercial audit samples test results to expected values.	Check to see if any QC results sheets are missing. Discuss any outliers or errors with other team members and correct those found. Re-run calculations. Re-run QC tests, if possible. Flag any problems that are not correctable.

D3. Reconciliation with Data Quality Objectives

The Project Manager and QA/QC Officer will compare the data with the objectives for precision, completeness, and accuracy provided in Section A7. The following data review decision tree (Figure D3-1) from the Massachusetts Volunteer Monitor's Guidebook to Quality Assurance

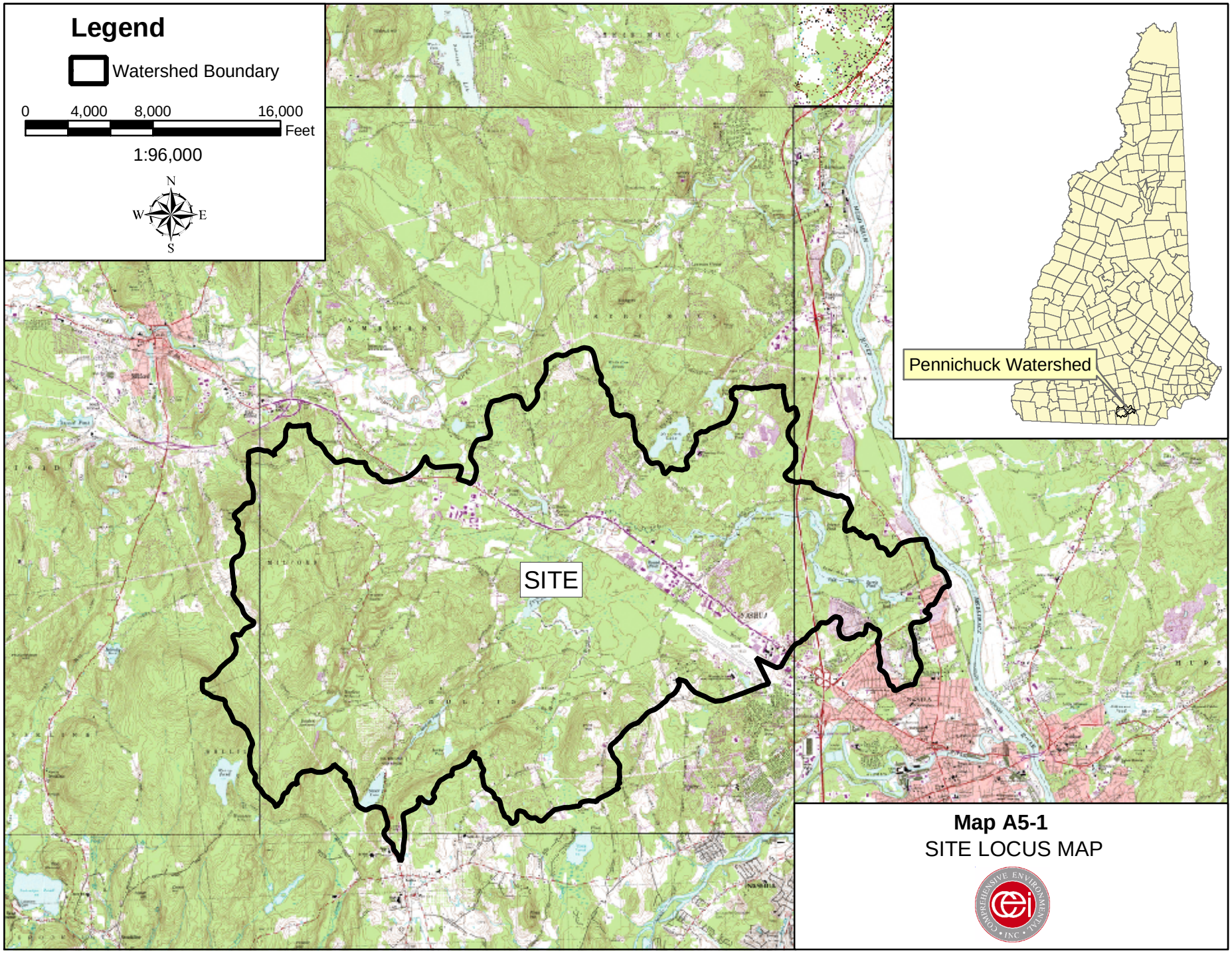
Project Plans (October 1, 2001) will serve as the basis for evaluating the quality of project data. Necessary corrective actions will be implemented, documented and initiated by the Project Manager and QA/QC Officer. Data quality objective failures due to equipment issues will result in the reassessment of calibration and maintenance procedures, with affected data so noted.

Figure D3-1. Data Review Decision Tree

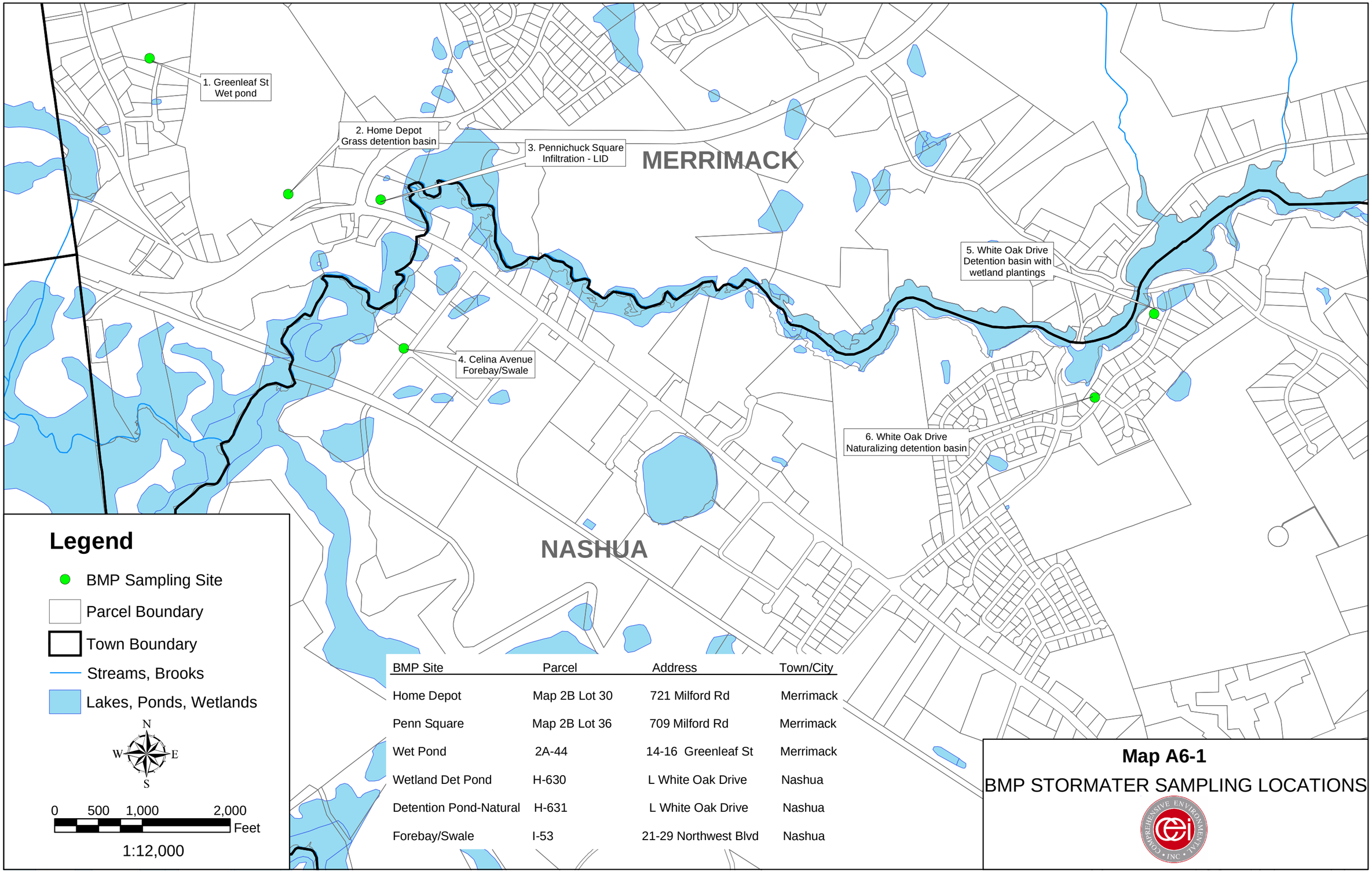


APPENDIX A

Maps



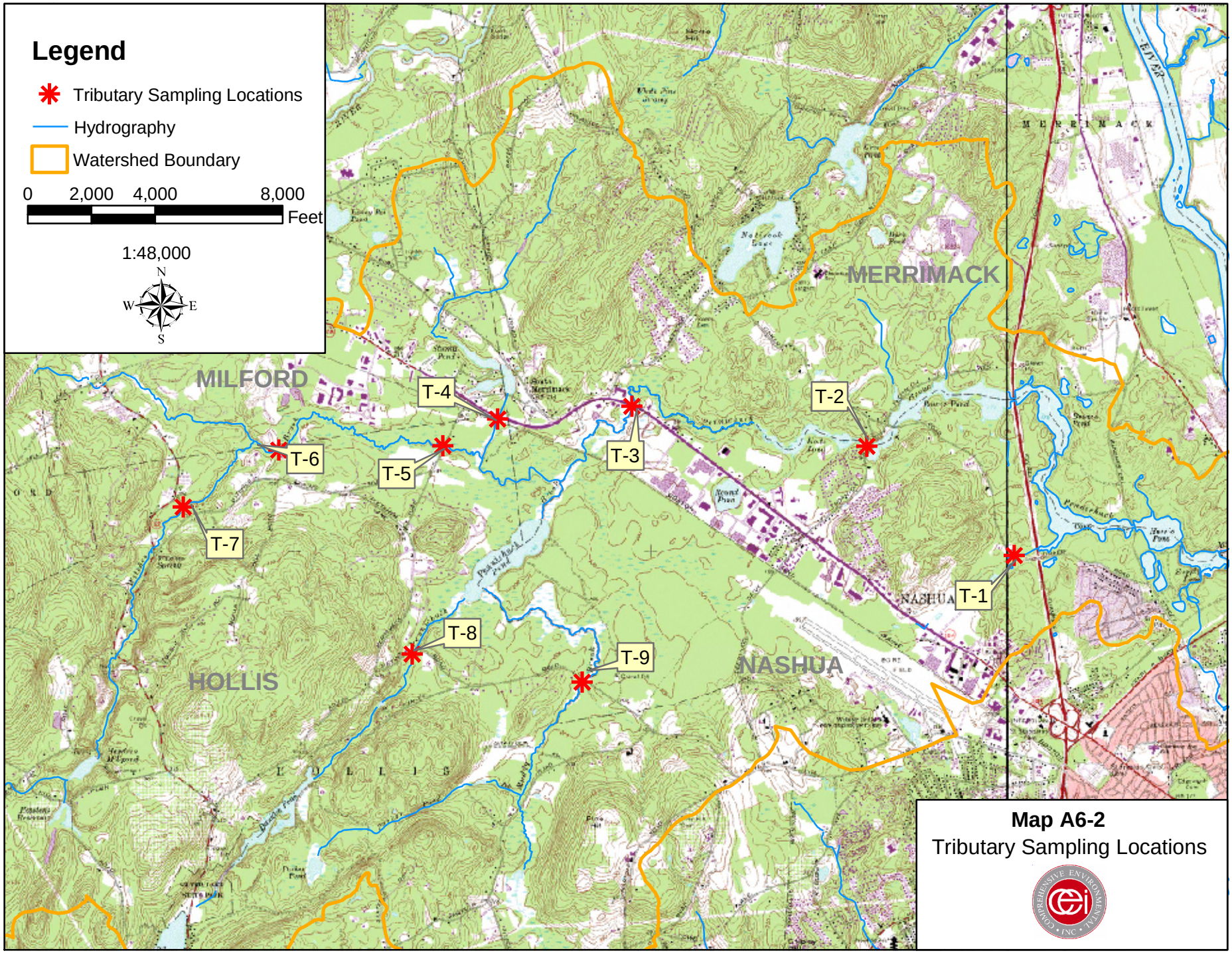
Map A5-1
SITE LOCUS MAP



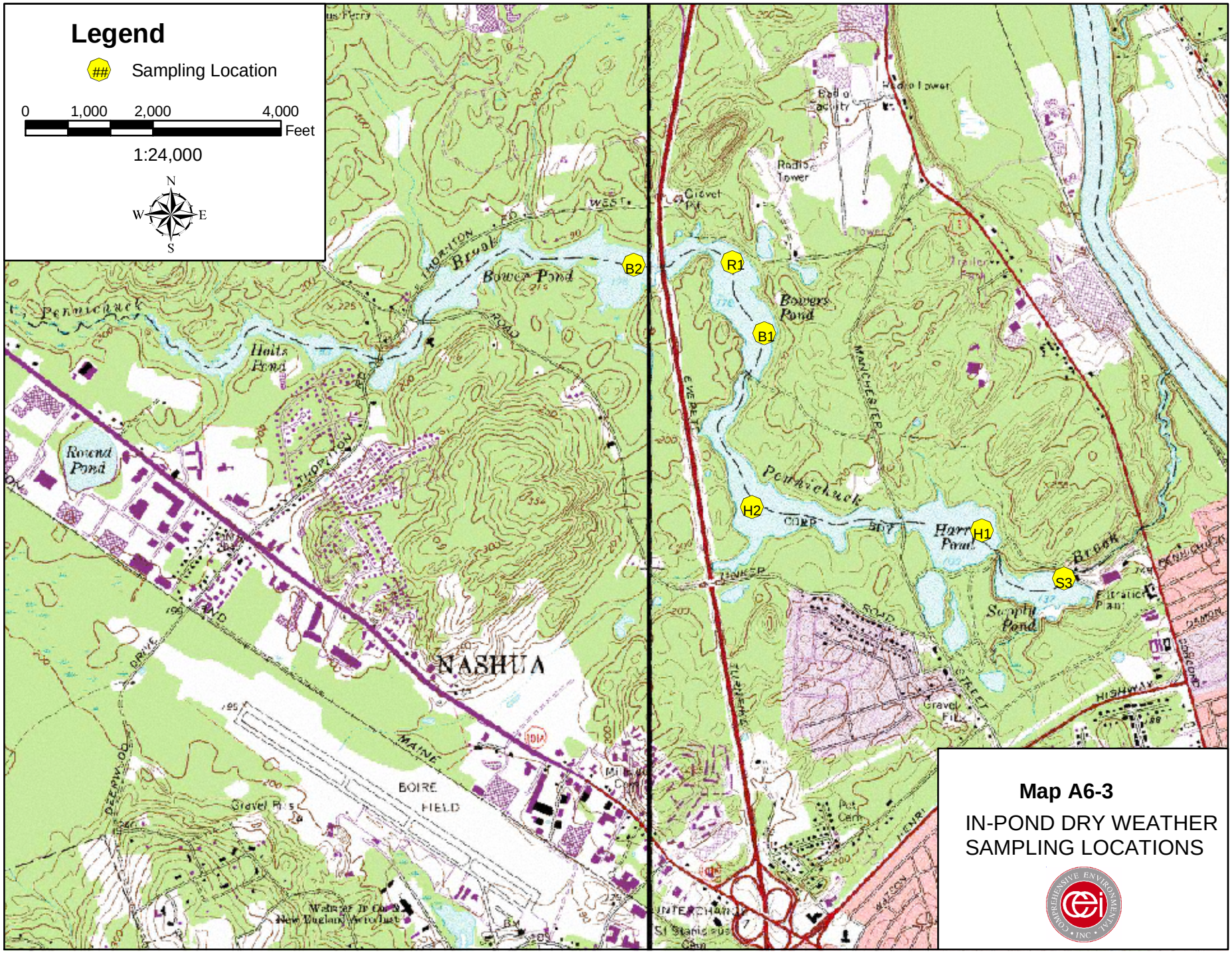
BMP Site	Parcel	Address	Town/City
Home Depot	Map 2B Lot 30	721 Milford Rd	Merrimack
Penn Square	Map 2B Lot 36	709 Milford Rd	Merrimack
Wet Pond	2A-44	14-16 Greenleaf St	Merrimack
Wetland Det Pond	H-630	L White Oak Drive	Nashua
Detention Pond-Natural	H-631	L White Oak Drive	Nashua
Forebay/Swale	I-53	21-29 Northwest Blvd	Nashua

Map A6-1

BMP STORMATER SAMPLING LOCATIONS



Map A6-2
Tributary Sampling Locations


Legend
Sampling Location
0 1,000 2,000 4,000
Feet
1:24,000
N
W
E
S
B2
R1
B1
H2
H1
S3
Bowers Pond
Penmichuck
Holts Pond
Round Pond
NASHUA
BOIRE FIELD
Harris Pond
Supply Pond
Radio Tower
Gravel Pit
Filtration Plant
Gravel Fill
Pet Cem
Map A6-3
IN-POND DRY WEATHER SAMPLING LOCATIONS

APPENDIX B

SWMM User's Manual

United States
Environmental Protection Agency

EPA/600/R-05/040
Revised May 2005

STORM WATER MANAGEMENT MODEL

USER'S MANUAL

Version 5.0

By

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NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
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DISCLAIMER

The information in this document has been funded wholly or in part by the U.S. Environmental Protection Agency (EPA). It has been subjected to the Agency's peer and administrative review, and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Although a reasonable effort has been made to assure that the results obtained are correct, the computer programs described in this manual are experimental. Therefore the author and the U.S. Environmental Protection Agency are not responsible and assume no liability whatsoever for any results or any use made of the results obtained from these programs, nor for any damages or litigation that result from the use of these programs for any purpose.

FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for reducing risks from threats to human health and the environment. The focus of the Laboratory's research program is on methods for the prevention and control of pollution to the air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites and ground water; and prevention and control of indoor air pollution. The goal of this research effort is to catalyze development and implementation of innovative, cost-effective environmental technologies; develop scientific and engineering information needed by EPA to support regulatory and policy decisions; and provide technical support and information transfer to ensure effective implementation of environmental regulations and strategies.

Water quality impairment due to runoff from urban and developing areas continues to be a major threat to the ecological health of our nation's waterways. The EPA Stormwater Management Model is a computer program that can assess the impacts of such runoff and evaluate the effectiveness of mitigation strategies. The modernized and updated version of the model described in this document will make it a more accessible and valuable tool for researchers and practitioners engaged in water resources and water quality planning and management.

Sally C. Gutierrez, Acting Director
National Risk Management Research Laboratory

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US EPA	CDM
Lewis Rossman	Robert Dickinson
Trent Schade	Carl Chan
Daniel Sullivan (retired)	Edward Burgess

The team would like to acknowledge the assistance provided by Wayne Huber (Oregon State University), Dennis Lai (US EPA), and Michael Gregory (CDM). We also want to acknowledge the contributions made by the following individuals to previous versions of SWMM that we drew heavily upon in this new version: John Aldrich, Douglas Ammon, Carl W. Chen, Brett Cunningham, Robert Dickinson, James Heaney, Wayne Huber, Miguel Medina, Russell Mein, Charles Moore, Stephan Nix, Alan Peltz, Don Polmann, Larry Roesner, Charles Rowney, and Robert Shubinsky. Finally, we wish to thank Wayne Huber, Thomas Barnwell (US EPA), Richard Field (US EPA), Harry Torno (US EPA retired) and William James (University of Guelph) for their continuing efforts to support and maintain the program over the past several decades.

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CHAPTER 1 - INTRODUCTION

1.1 What is SWMM

The EPA Storm Water Management Model (SWMM) is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each subcatchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps.

SWMM was first developed in 1971[1] and has undergone several major upgrades since then[2]. It continues to be widely used throughout the world for planning, analysis and design related to storm water runoff, combined sewers, sanitary sewers, and other drainage systems in urban areas, with many applications in non-urban areas as well. The current edition, Version 5, is a complete re-write of the previous release. Running under Windows, SWMM 5 provides an integrated environment for editing study area input data, running hydrologic, hydraulic and water quality simulations, and viewing the results in a variety of formats. These include color-coded drainage area and conveyance system maps, time series graphs and tables, profile plots, and statistical frequency analyses.

This latest re-write of SWMM was produced by the Water Supply and Water Resources Division of the U.S. Environmental Protection Agency's National Risk Management Research Laboratory with assistance from the consulting firm of CDM, Inc

1.2 Modeling Capabilities

SWMM accounts for various hydrologic processes that produce runoff from urban areas. These include:

- time-varying rainfall
- evaporation of standing surface water
- snow accumulation and melting
- rainfall interception from depression storage
- infiltration of rainfall into unsaturated soil layers

[1] Metcalf & Eddy, Inc., University of Florida, Water Resources Engineers, Inc. "Storm Water Management Model, Volume I – Final Report", 11024DOC07/71, Water Quality Office, Environmental Protection Agency, Washington, DC, July 1971.
[2] Huber, W. C. and Dickinson, R.E., "Storm Water Management Model, Version 4: User's Manual", EPA/600/3-88/001a, Environmental Research Laboratory, U.S. Environmental Protection Agency, Athens, GA, October 1992.

- percolation of infiltrated water into groundwater layers
- interflow between groundwater and the drainage system
- nonlinear reservoir routing of overland flow

Spatial variability in all of these processes is achieved by dividing a study area into a collection of smaller, homogeneous subcatchment areas, each containing its own fraction of pervious and impervious sub-areas. Overland flow can be routed between sub-areas, between subcatchments, or between entry points of a drainage system.

SWMM also contains a flexible set of hydraulic modeling capabilities used to route runoff and external inflows through the drainage system network of pipes, channels, storage/treatment units and diversion structures. These include the ability to:

- handle networks of unlimited size
- use a wide variety of standard closed and open conduit shapes as well as natural channels
- model special elements such as storage/treatment units, flow dividers, pumps, weirs, and orifices
- apply external flows and water quality inputs from surface runoff, groundwater interflow, rainfall-dependent infiltration/inflow, dry weather sanitary flow, and user-defined inflows
- utilize either kinematic wave or full dynamic wave flow routing methods
- model various flow regimes, such as backwater, surcharging, reverse flow, and surface ponding
- apply user-defined dynamic control rules to simulate the operation of pumps, orifice openings, and weir crest levels.

In addition to modeling the generation and transport of runoff flows, SWMM can also estimate the production of pollutant loads associated with this runoff. The following processes can be modeled for any number of user-defined water quality constituents:

- dry-weather pollutant buildup over different land uses
- pollutant washoff from specific land uses during storm events
- direct contribution of rainfall deposition
- reduction in dry-weather buildup due to street cleaning
- reduction in washoff load due to BMPs
- entry of dry weather sanitary flows and user-specified external inflows at any point in the drainage system
- routing of water quality constituents through the drainage system
- reduction in constituent concentration through treatment in storage units or by natural processes in pipes and channels.

1.3 Typical Applications of SWMM

Since its inception, SWMM has been used in thousands of sewer and stormwater studies throughout the world. Typical applications include:

- design and sizing of drainage system components for flood control
- sizing of detention facilities and their appurtenances for flood control and water quality protection
- flood plain mapping of natural channel systems
- designing control strategies for minimizing combined sewer overflows
- evaluating the impact of inflow and infiltration on sanitary sewer overflows
- generating non-point source pollutant loadings for waste load allocation studies
- evaluating the effectiveness of BMPs for reducing wet weather pollutant loadings.

1.4 Installing EPA SWMM

EPA SWMM Version 5 is designed to run under the Windows 98/NT/ME/2000/XP operating system of an IBM/Intel-compatible personal computer. It is distributed as a single file, **epaswmm5_setup.exe**, which contains a self-extracting setup program. To install EPA SWMM:

1. Select **Run** from the Windows Start menu.
2. Enter the full path and name of the **epaswmm5_setup.exe** file or click the **Browse** button to locate it on your computer.
3. Click the **OK** button type to begin the setup process.

The setup program will ask you to choose a folder (directory) where the SWMM program files will be placed. The default folder is **c:\Program Files\EPA SWMM 5.0**. After the files are installed your Start Menu will have a new item named **EPA SWMM 5.0**. To launch SWMM, simply select this item off of the Start Menu, then select EPA SWMM 5.0 from the submenu that appears. (The name of the executable file that runs SWMM under Windows is epaswmm5.exe.)

If SWMM is being installed within a multi-user network environment, then the network administrator may wish to install a shortcut to SWMM 5 on each user's desktop whose target entry includes the name of the SWMM 5 executable followed by **/s <userfolder>**, where <userfolder> is the name of the folder where the user's personal SWMM settings will be stored. An example might be:

"c:\Program Files\EPA SWMM 5.0\epaswmm5.exe" /s "My Folders\SWMM5\".

This will allow SWMM to save the user's personal program settings to a different location than where SWMM was installed so it will not overwrite any previously saved settings from other users.

To remove EPA SWMM from your computer, do the following:

1. Select **Settings** from the Windows Start menu.
2. Select **Control Panel** from the Settings menu.
3. Double-click on the **Add/Remove Programs** item.
4. Select **EPA SWMM 5.0** from the list of programs that appears.
5. Click the **Add/Remove** button.

1.5 Steps in Using SWMM

One typically carries out the following steps when using SWMM to model stormwater runoff over a study area:

1. Specify a default set of options and object properties to use (see Section 5.4).
2. Draw a network representation of the physical components of the study area (see Section 6.2).
3. Edit the properties of the objects that make up the system (see Section 6.4).
4. Select a set of analysis options (see Section 8.1).
5. Run a simulation (see Section 8.2).
6. View the results of the simulation (see Chapter 9).

Alternatively, a modeler may convert an input file from an older version of EPA SWMM instead of developing a new model as in Steps 1 through 4.

1.6 About This Manual

Chapter 2 presents a short tutorial to help get started using EPA SWMM. It shows how to add objects to a SWMM project, how to edit the properties of these objects, how to run a single event simulation for both hydrology and water quality, and how to run a long-term continuous simulation.

Chapter 3 provides background material on how SWMM models stormwater runoff within a drainage area. It discusses the behavior of the physical components that comprise a stormwater drainage area and collection system as well as how additional modeling information, such as rainfall quantity, dry weather sanitary inflows, and operational control, are handled. It also provides an overview of how the numerical simulation of system hydrology, hydraulics and water quality behavior is carried out.

Chapter 4 shows how the EPA SWMM graphical user interface is organized. It describes the functions of the various menu options and toolbar buttons, and how the three main windows – the Study Area Map, the Browser panel, and the Property Editor—are used.

Chapter 5 discusses the project files that store all of the information contained in a SWMM model of a drainage system. It shows how to create, open, and save these files as

well as how to set default project options. It also discusses how to register calibration data that are used to compare simulation results against actual measurements.

Chapter 6 describes how one goes about building a network model of a drainage system with EPA SWMM. It shows how to create the various physical objects (subcatchment areas, drainage pipes and channels, pumps, weirs, storage units, etc.) that make up a system, how to edit the properties of these objects, and how to describe the way that externally imposed inflows, boundary conditions and operational controls change over time.

Chapter 7 explains how to use the study area map that provides a graphical view of the system being modeled. It shows how to view different design and computed parameters in color-coded fashion on the map, how to re-scale, zoom, and pan the map, how to locate objects on the map, how to utilize a backdrop image, and what options are available to customize the appearance of the map.

Chapter 8 shows how to run a simulation of a SWMM model. It describes the various options that control how the analysis is made and offers some troubleshooting tips to use when examining simulation results.

Chapter 9 discusses the various ways in which the results of an analysis can be viewed. These include different views of the study area map, various kinds of graphs and tables, and several different types of special reports.

Chapter 10 explains how to print and copy the results discussed in Chapter 9.

Chapter 11 describes how EPA SWMM can use different types of interface files to make simulations runs more efficient.

The manual also contains several appendixes:

Appendix A - provides several useful tables of parameter values, including a table of units of expression for all design and computed parameters.

Appendix B - lists the editable properties of all visual objects that can be displayed on the study area map and be selected for editing using point and click.

Appendix C - describes the specialized editors available for setting the properties of non-visual objects.

Appendix D - provides instructions for running the command line version of SWMM and includes a detailed description of the format of a project file.

Appendix E - lists all of the error messages and their meaning that SWMM can produce.

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CHAPTER 2 - QUICK START TUTORIAL

This chapter provides a tutorial on how to use EPA SWMM. If you are not familiar with the elements that comprise a drainage system, and how these are represented in a SWMM model, you might want to review the material in Chapter 3 first.

2.1 Example Study Area

In this tutorial we will model the drainage system serving a 12-acre residential area. The system layout is shown in Figure 2-1 and consists of subcatchment areas[3] S1 through S3, storm sewer conduits C1 through C4, and conduit junctions J1 through J4. The system discharges to a creek at the point labeled Out1. We will first go through the steps of creating the objects shown in this diagram on SWMM's study area map and setting the various properties of these objects. Then we will simulate the water quantity and quality response to a 3-inch, 6-hour rainfall event, as well as a continuous, multi-year rainfall record.

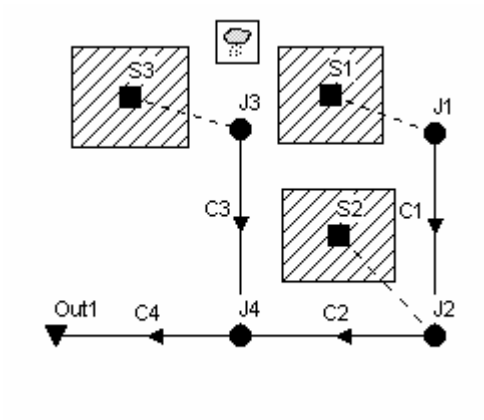

Figure 2-1. Example study area.

2.2 Project Setup

Our first task is to create a new SWMM project and make sure that certain default options are selected. Using these defaults will simplify the data entry tasks later on.

1. Launch EPA SWMM if it is not already running and select **File >> New** from the Main Menu bar to create a new project.
2. Select **Project >> Defaults** to open the Project Defaults dialog.

[3] A subcatchment is an area of land containing a mix of pervious and impervious surfaces whose runoff drains to a common outlet point, which could be either a node of the drainage network or another subcatchment.

3. On the ID Labels page of the dialog, set the ID Prefixes as shown in Figure 2-2. This will make SWMM automatically label new objects with consecutive numbers following the designated prefix.

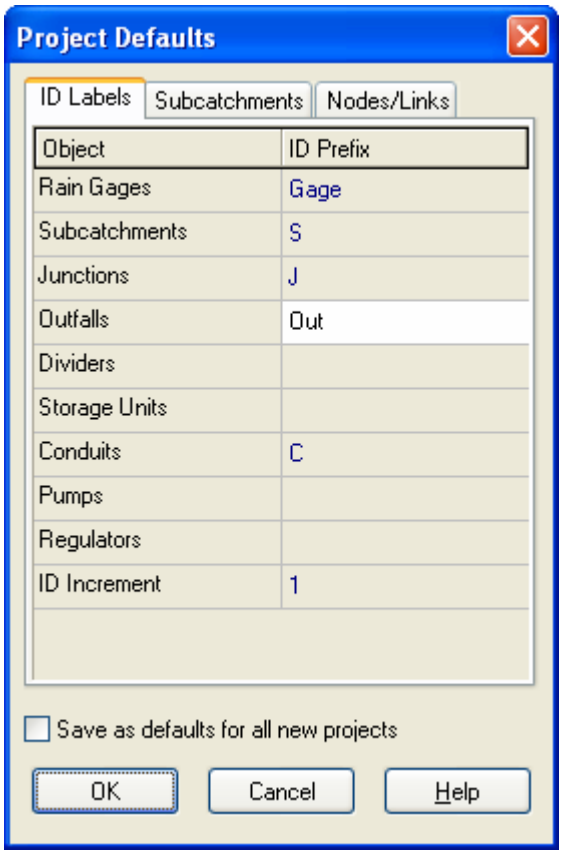

Figure 2-2. Default ID labeling for tutorial example.

4. On the Subcatchments page of the dialog set the following default values:

Area	4
Width	400
% Slope	0.5
% Imperv.	50
N-Imperv.	0.01
N-Perv.	0.10
Dstore-Imperv.	0.05
Dstore-Perv	0.05
%Zero-Imperv.	25
Infil. Model	<click to edit>
- *Method*	Green-Ampt
- *Suction Head*	3.5
- *Conductivity*	0.5
- *Initial Deficit*	0.26

5. On the Nodes/Links page set the following default values:

Node Invert	0
Node Max. Depth	4
Flow Units	CFS
Conduit Length	400
Conduit Geometry	<click to edit>
- Barrels	1
- Shape	Circular
- Max. Depth	1.0
Conduit Roughness	0.01
Routing Model	Kinematic Wave

6. Click **OK** to accept these choices and close the dialog. If you wanted to save these choices for all future new projects you could check the **Save** box at the bottom of the form before accepting it.

Next we will set some map display options so that ID labels and symbols will be displayed as we add objects to the study area map, and links will have direction arrows.

1. Select **View >> Map Options** to bring up the Map Options dialog (see Figure 2-3).
2. Select the Subcatchments page, set the Fill Style to Diagonal and the Symbol Size to **5**.
3. Then select the Nodes page and set the Node Size to **5**.
4. Select the Annotation page and check off the boxes that will display ID labels for Areas, Nodes, and Links. Leave the others un-checked.
5. Finally, select the Flow Arrows page, select the Filled arrow style, and set the arrow size to **7**.
6. Click the **OK** button to accept these choices and close the dialog.

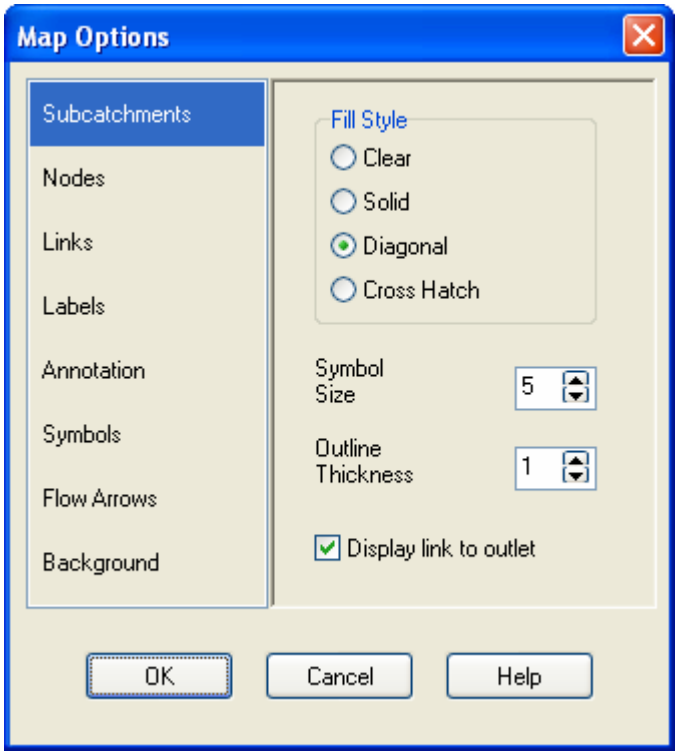

Figure 2-3. Map Options dialog.

Before placing objects on the map we should set its dimensions.

1. Select **View >> Dimensions** to bring up the Map Dimensions dialog.
2. You can leave the dimensions at their default values for this example.

Finally, look in the status bar at the bottom of the main window and check that the Auto-Length feature is off. If it is on, then right-click over the status bar and select "Auto-Length Off" from the popup menu that appears.

2.3 Drawing Objects

We are now ready to begin adding components to the Study Area Map[4]. We will start with the subcatchments.

[4] Drawing objects on the map is just one way of creating a project. For large projects it might be more convenient to first construct a SWMM project file external to the program. The project file is a text file that describes each object in a specified format as described in Appendix D of this manual. Data extracted from various sources, such as CAD drawings or GIS files, can be used to create the project file.

1. Begin by clicking the button on the Object Toolbar. (If the toolbar is not visible then select **View >> Toolbars >> Object**). Notice how the mouse cursor changes shape to a pencil.
2. Move the mouse to the map location where one of the corners of subcatchment **S1** lies and left-click the mouse.
3. Do the same for the next three corners and then right-click the mouse (or hit the Enter key) to close up the rectangle that represents subcatchment **S1**. You can press the **Esc** key if instead you wanted to cancel your partially drawn subcatchment and start over again. Don't worry if the shape or position of the object isn't quite right. We will go back later and show how to fix this.
4. Repeat this process for subcatchments **S2** and **S3**[5].

Observe how sequential ID labels are generated automatically as we add objects to the map.

Next we will add in the junction nodes and the outfall node that comprise part of the drainage network.

1. To begin adding junctions, click the button on the Object Toolbar.
2. Move the mouse to the position of junction **J1** and left-click it. Do the same for junctions **J2** through **J4**.
3. To add the outfall node, click the button on the Object Toolbar, move the mouse to the outfall's location on the map, and left-click. Note how the outfall was automatically given the name **Out1**.

At this point your map should look something like that shown in Figure 2.4.

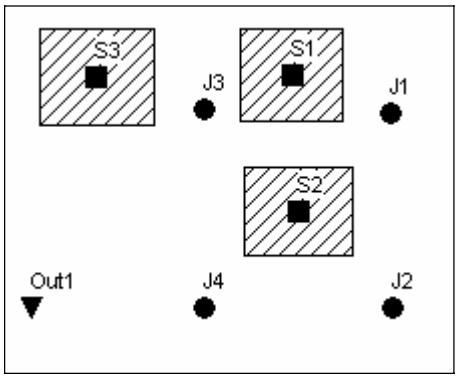

Figure 2-4. Subcatchments and nodes for example study area.

Now we will add the storm sewer conduits that connect our drainage system nodes to one another. (You must have created a link's end nodes as described previously before you can create the link.) We will begin with conduit **C1,** which connects junction **J1** to **J2**.

[5] If you right-click (or press **Enter**) after adding the first point of a subcatchment's outline, the subcatchment will be shown as just a single point.

1. Click the button on the Object Toolbar. The mouse cursor changes shape to a crosshair.
2. Click the mouse on junction **J1**. Note how the mouse cursor changes shape to a pencil.
3. Move the mouse over to junction **J2** (note how an outline of the conduit is drawn as you move the mouse) and left-click to create the conduit. You could have cancelled the operation by either right clicking or by hitting the <**Esc**> key.
4. Repeat this procedure for conduits **C2** through **C4**.

Although all of our conduits were drawn as straight lines, it is possible to draw a curved link by left-clicking at intermediate points where the direction of the link changes before clicking on the end node.

To complete the construction of our study area schematic we need to add a rain gage.

1. Click the Rain Gage button on the Object Toolbar.
2. Move the mouse over the Study Area Map to where the gage should be located and left-click the mouse.

At this point we have completed drawing the example study area. Your system should look like the one in Figure 2.1. If a rain gage, subcatchment or node is out of position you can move it by doing the following:

1. If the button is not already depressed, click it to place the map in Object Selection mode.
2. Click on the object to be moved.
3. Drag the object with the left mouse button held down to its new position.

To re-shape a subcatchment's outline:

1. With the map in Object Selection mode, click on the subcatchment's centroid (indicated by a solid square within the subcatchment) to select it.
2. Then click the button on the Map Toolbar to put the map into Vertex Selection mode.
3. Select a vertex point on the subcatchment outline by clicking on it (note how the selected vertex is indicated by a filled solid square).
4. Drag the vertex to its new position with the left mouse button held down.
5. If need be, vertices can be added or deleted from the outline by right-clicking the mouse and selecting the appropriate option from the popup menu that appears.
6. When finished, click the button to return to Object Selection mode.

This same procedure can also be used to re-shape a link.

2.4 Setting Object Properties

As visual objects are added to our project, SWMM assigns them a default set of properties. To change the value of a specific property for an object we must select the object into the Property Editor (see Figure 2-5). There are several different ways to do this. If the Editor is already visible, then you can simply click on the object or select it from the Data page of the Browser Panel of the main window. If the Editor is not visible then you can make it appear by one of the following actions:

- double-click the object on the map,
- or right-click on the object and select Properties from the pop-up menu that appears,
- or select the object from the Data page of the Browser panel and then click the Browser's button.

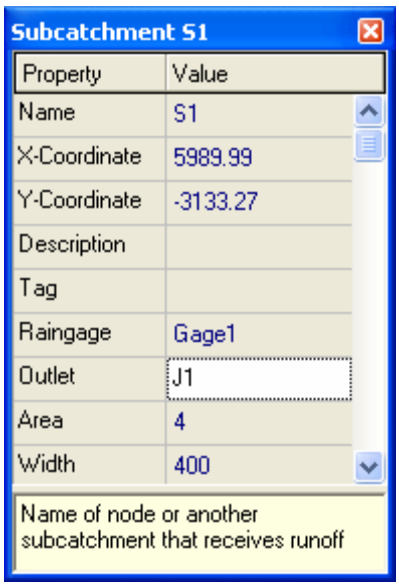

Figure 2-5. Property Editor window.

Whenever the Property Editor has the focus you can press the F1 key to obtain a more detailed description of the properties listed.

Two key properties of our subcatchments that need to be set are the rain gage that supplies rainfall data to the subcatchment and the node of the drainage system that receives runoff from the subcatchment. Since all of our subcatchments utilize the same rain gage, **Gage1**, we can use a shortcut method to set this property for all subcatchments at once:

1. From the main menu select **Edit >>Select All**.
2. Then select **Edit >> Group Edit** to make a Group Editor dialog appear (see Figure 2-6).
3. Select **Subcatchment** as the type of object to edit, **Rain Gage** as the property to edit, and type in **Gage1** as the new value.

4. Click **OK** to change the rain gage of all subcatchments to **Gage1**. A confirmation dialog will appear noting that 3 subcatchments have changed. Select "**No**" when asked to continue editing.

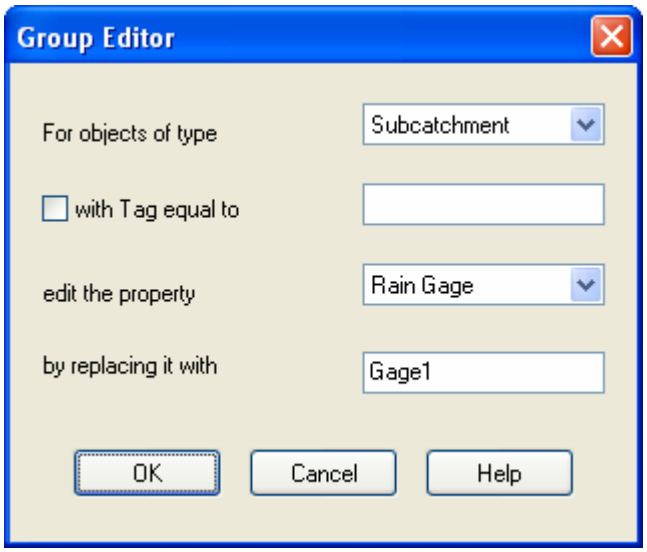

Figure 2-6. Group Editor dialog.

Because the outlet nodes vary by subcatchment, we must set them individually as follows:

1. Double click on subcatchment **S1** or select it from the Data Browser and click the Browser's button to bring up the Property Editor.
2. Type **J1** in the Outlet field and press **Enter**. Note how a dotted line is drawn between the subcatchment and the node.
3. Click on subcatchment **S2** and enter **J2** as its Outlet.
4. Click on subcatchment **S3** and enter **J3** as its Outlet.

We also wish to represent area **S3** as being less developed than the others. Select **S3** into the Property Editor and set its % Imperviousness to **25**.

The junctions and outfall of our drainage system need to have invert elevations assigned to them. As we did with the subcatchments, select each junction individually into the Property Editor and set its Invert Elevation to the value shown below[6].

Node	*Invert*
J1	96
J2	90
J3	93
J4	88
Out1	85

[6] An alternative way to move from one object of a given type to the next in order (or to the previous one) in the Property Editor is to hit the Page Down (or Page Up) key.

Only one of the conduits in our example system has a non-default property value. This is conduit **C4**, the outlet pipe, whose diameter should be 1.5 instead of 1 ft. To change its diameter:

1. Select conduit **C4** into the Property Editor (by either double-clicking anywhere on the conduit itself or by selecting it in the Data Browser and clicking the button).
2. Select the Shape field and click the ellipsis button (or press <**Enter**>).
3. In the Cross-Section Editor dialog that appears (see Figure 2-7), set the Max. Depth value to **1.5** and then click the **OK** button.

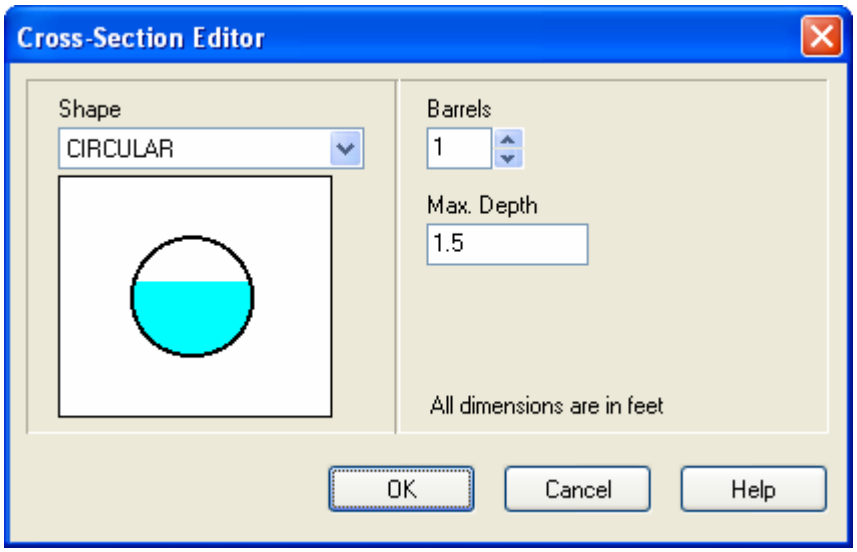

Figure 2-7. Cross-Section Editor dialog.

In order to provide a source of rainfall input to our project we need to set the rain gage's properties. Select **Gage1** into the Property Editor and set the following properties:

Rain Format	INTENSITY
Rain Interval	1:00
Data Source	TIMESERIES
Series Name	TS1

As mentioned earlier, we want to simulate the response of our study area to a 3-inch, 6-hour design storm. A time series named **TS1** will contain the hourly rainfall intensities that make up this storm. Thus we need to create a time series object and populate it with data. To do this:

1. From the Data Browser select the **Time Series** category of objects.
2. Click the button on the Browser to bring up the Time Series Editor dialog (see Figure 2-8)[7].

[7] The Time Series Editor can also be launched directly from the Rain Gage Property Editor by selecting the editor's Series Name field and double clicking on it.

3. Enter **TS1** in the Time Series Name field.
4. Enter the values shown in Figure 2.8 into the Time and Value columns of the data entry grid (leave the Date column blank[8]).
5. You can click the **View** button on the dialog to see a graph of the time series values. Click the **OK** button to accept the new time series.

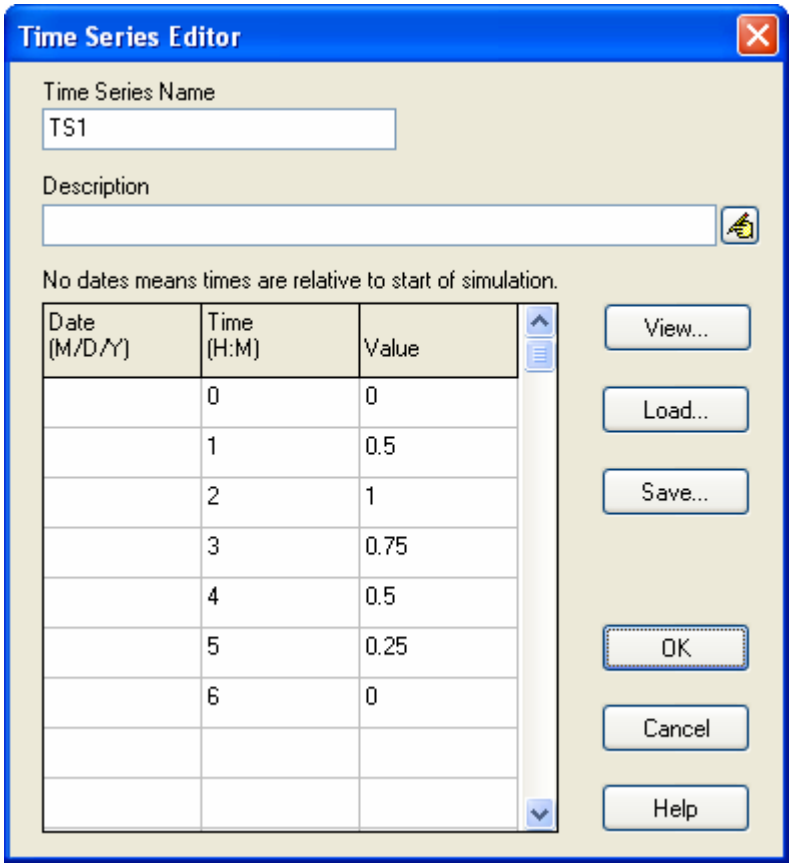

Figure 2-8. Time Series Editor dialog.

Having completed the initial design of our example project it is a good idea to give it a title and save our work to a file at this point. To do this:

1. Select the **Title/Notes** category from the Data Browser and click the button.
2. In the Project Title/Notes dialog that appears (see Figure 2-9), enter "Tutorial Example" as the title of our project and click the **OK** button to close the dialog.
3. From the **File** menu select the **Save As** option.

[8] Leaving off the dates for a time series means that SWMM will interpret the time values as hours from the start of the simulation. Otherwise, the time series follows the date/time values specified by the user.

4. In the Save As dialog that appears, select a folder and file name under which to save this project. We suggest naming the file tutorial.inp. (An extension of .inp will be added to the file name if one is not supplied.)
5. Click **Save** to save the project to file.

The project data are saved to the file in a readable text format. You can view what the file looks like by selecting **Project >> Details** from the main menu. To open our project at some later time, you would select the **Open** command from the **File** menu.

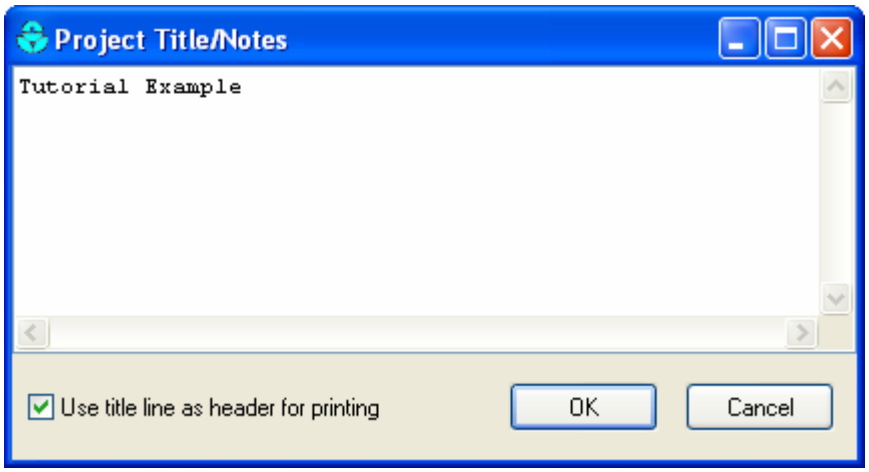

Figure 2-9. Title/Notes Editor.

2.5 Running a Simulation

Setting Simulation Options

Before analyzing the performance of our example drainage system we need to set some options that determine how the analysis will be carried out. To do this:

1. From the Data Browser, select the **Options** category and click the button.
2. On the General page of the Simulation Options dialog that appears (see Figure 2-10), select **Kinematic Wave** as the flow routing method. The flow units should already be set to **CFS** and the infiltration method to **Green-Ampt**. The Allow Ponding option should be unchecked.
3. On the Dates page of the dialog, set the End Analysis time to **12:00:00**.
4. On the Time Steps page, set the Routing Time Step to **60** seconds.
5. Click **OK** to close the Simulation Options dialog.

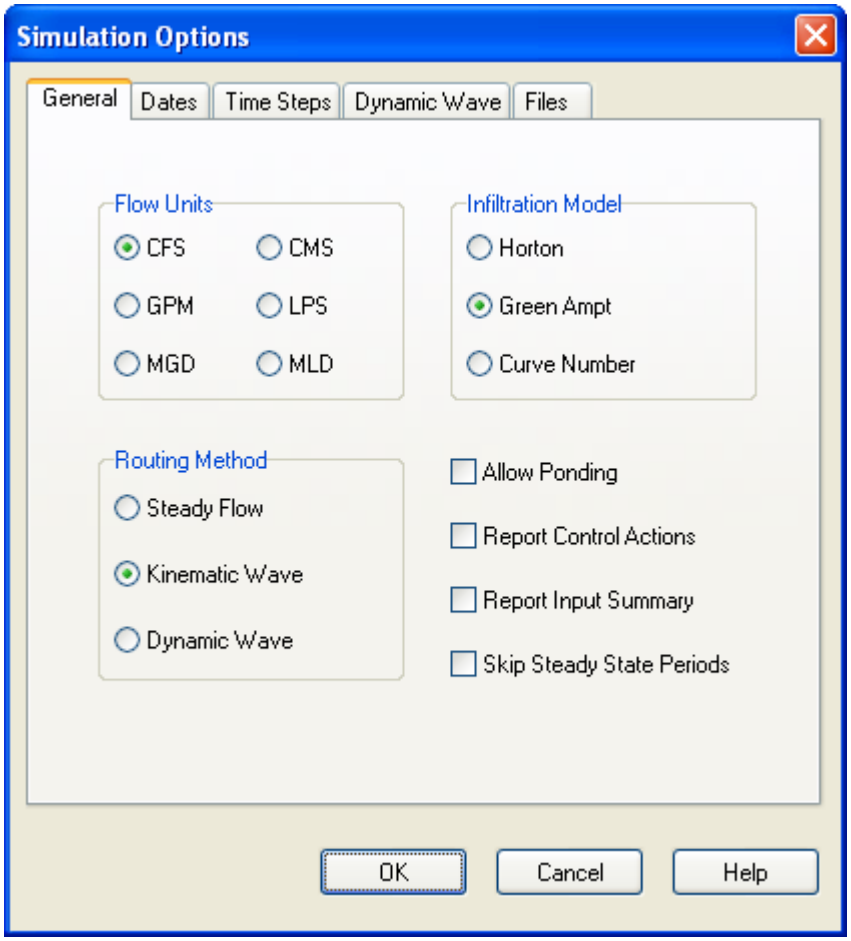

Figure 2-10. Simulation Options dialog.

Running a Simulation

We are now ready to run the simulation. To do so, select **Project >> Run Simulation** (or click the button). If there was a problem with the simulation, a Status Report will appear describing what errors occurred. Upon successfully completing a run, there are numerous ways in which to view the results of the simulation. We will illustrate just a few here.

Viewing the Status Report

The Status Report contains useful summary information about the results of a simulation run. To view the report, select **Report >> Status**. A portion of the report for the system just analyzed is shown in Figure 2-11. The full report indicates the following:

- The quality of the simulation is quite good, with negligible mass balance continuity errors for both runoff and routing (-0.23% and 0.03%, respectively, if all data were entered correctly).
- Of the 3 inches of rain that fell on the study area, 1.75 infiltrated into the ground and essentially the remainder became runoff.

- The Node Depth Summary table (not shown in Figure 2-11) indicates there was internal flooding in the system at node **J2**[9].
- The Conduit Flow Summary table (also not shown in Figure 2-11) shows that Conduit **C2**, just downstream of node **J2**, was surcharged and therefore appears to be slightly undersized.

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0
----------------------------------------------

Tutorial Example

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... KW
Starting Date ............ JUN-27-2002 00:00:00
Ending Date .............. JUN-27-2002 12:00:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 00:01:00
Report Time Step ......... 00:15:00


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         3.000         3.000
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         1.750         1.750
Surface Runoff ...........         1.241         1.241
Final Surface Storage ....         0.016         0.016
Continuity Error (%) .....        -0.228

**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         1.246         0.406
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
Internal Flooding ........         0.054         0.018
External Outflow .........         1.192         0.388
Evaporation Loss .........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.029
```

Figure 2-11. Portion of the Status Report for initial simulation run.

[9] In SWMM, flooding will occur whenever the water surface at a node exceeds the maximum defined depth. Normally such water will be lost from the system. The option also exists to have this water pond atop the node and be re-introduced into the drainage system when capacity exists to do so.

Viewing Results on the Map

Simulation results (as well as some design parameters, such as subcatchment area, node invert elevation, link maximum depth) can be viewed in color-coded fashion on the study area map. To view a particular variable in this fashion:

1. Select the Map page of the Browser panel.
2. Select the variables to view for Subcatchments, Nodes, and Links from the dropdown combo boxes labeled Subcatch View, Node View, and Link View, respectively. In Figure 2-12, subcatchment runoff and link flow have been selected for viewing.
3. The color-coding used for a particular variable is displayed with a legend on the study area map. To toggle the display of a legend, select **View >> Legends**.
4. To move a legend to another location, drag it with the left mouse button held down.
5. To change the color-coding and the breakpoint values for different colors, select **View >> Legends >> Modify** and then the pertinent class of object (or if the legend is already visible, simply right-click on it). To view numerical values for the variables being displayed on the map, select **View >> Map Options** and then select the Annotation page of the Map Options dialog. Use the check boxes for Areas (i.e., sub-catchments), Nodes, and Links in the Values panel to specify what kind of annotation to add.
6. The Date / Time / Elapsed Time controls on the Map Browser can be used to move through the simulation results in time. Figure 2-12 depicts results at 5 hour and 45 minutes into the simulation.
7. To animate the map display through time, select **View >> Toolbars >> Animator** and use the controls on the Animator Toolbar to control the animation. For example, pressing the button will run the animation forward in time.

Viewing a Time Series Plot

To generate a time series plot of a simulation result:

1. Select **Report >> Graph >> Time Series** or simply click on the Standard Toolbar and select **Time Series** from the pull-down menu that appears.
2. A Time Series Plot dialog will appear. It is used to select the objects and variables to be plotted.

For our example, the Time Series Plot dialog can be used to graph the flow in conduits **C1** and **C2** as follows (refer to Figure 2-14):

1. Select **Links** as the Object Category.
2. Select **Flow** as the Variable to plot.
3. Click on conduit **C1** (either on the map or in the Data Browser) and then click in the dialog to add it to the list of links plotted. Do the same for conduit **C2**.
4. Press **OK** to create the plot, which should look like the graph in Figure 2-15.

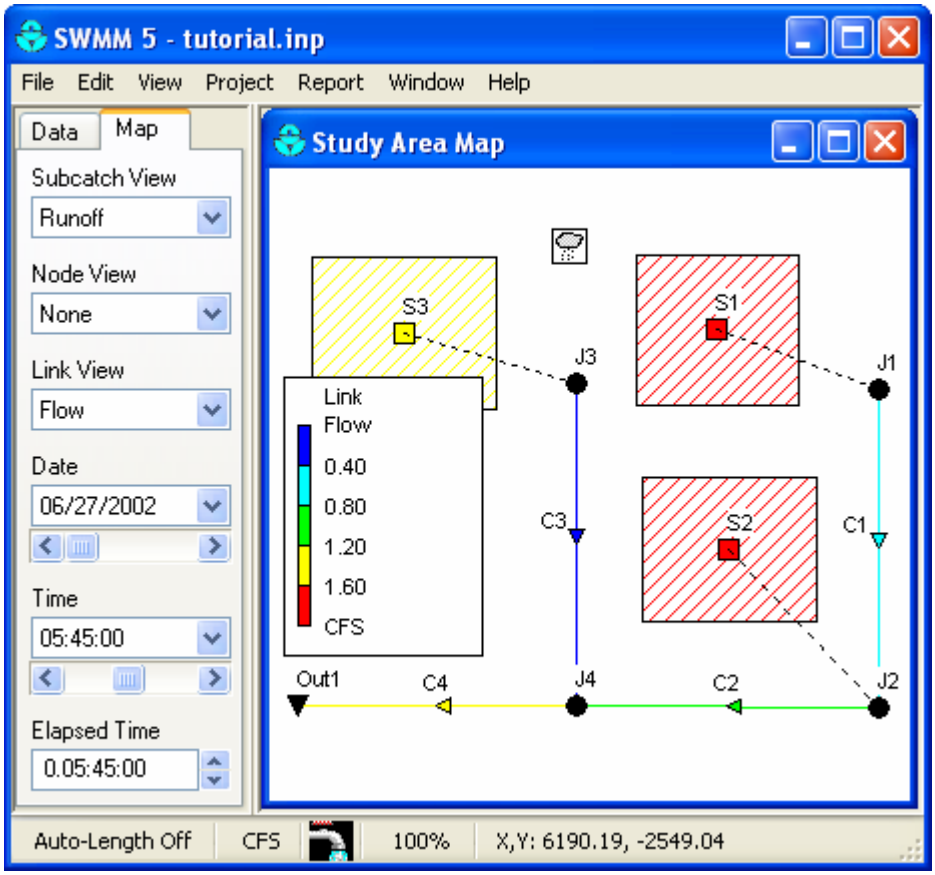

Figure 2-12. Example of viewing color-coded results on the Study Area Map.

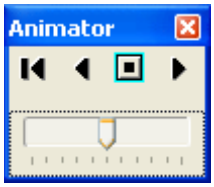

Figure 2-13. The Animator Toolbar.

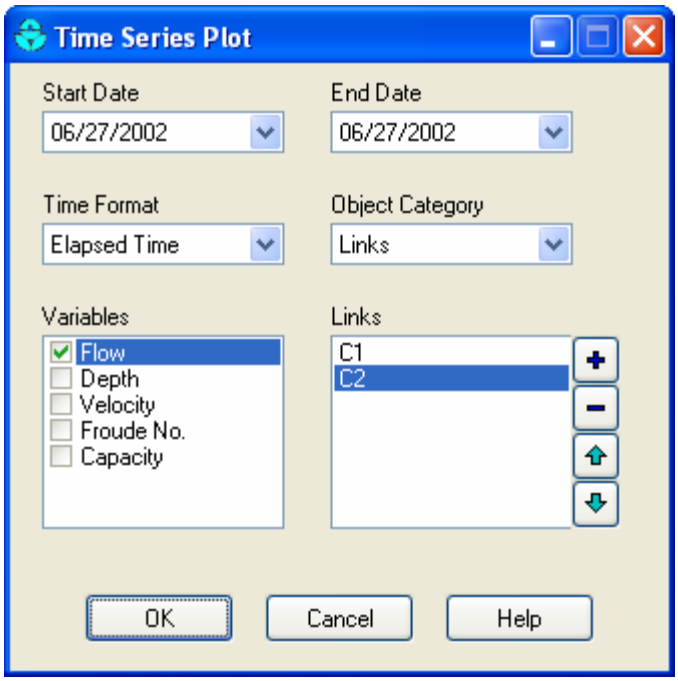

Figure 2-14. Time Series Plot dialog.

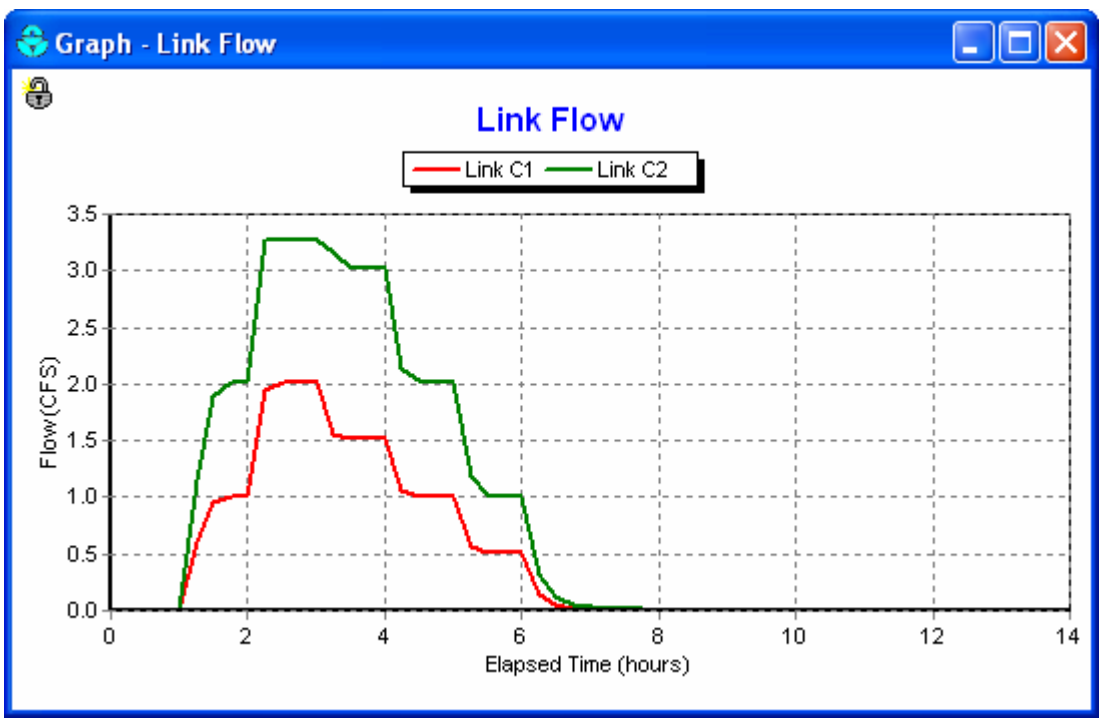

Figure 2-15. Time Series plot of results from initial simulation run.

After a plot is created you can:

- customize its appearance by selecting **Report >> Options** or right clicking on the plot,
- copy it to the clipboard and paste it into another application by selecting **Edit >> Copy To** or clicking on the Standard Toolbar
- print it by selecting **File >> Print** or **File >> Print Preview** (use **File >> Page Setup** first to set margins, orientation, etc.).

Viewing a Profile Plot

SWMM can generate profile plots showing how water surface depth varies across a path of connected nodes and links. Let's create such a plot for the conduits connecting junction **J1** to the outfall **Out1** of our example drainage system. To do this:

1. Select **Report >> Graph >> Profile** or simply click on the Standard Toolbar and select **Profile** from the pull-down menu that appears.
2. Either enter **J1** in the Start Node field of the Profile Plot dialog that appears (see Figure 2-16) or select it on the map or from the Data Browser and click the button next to the field.

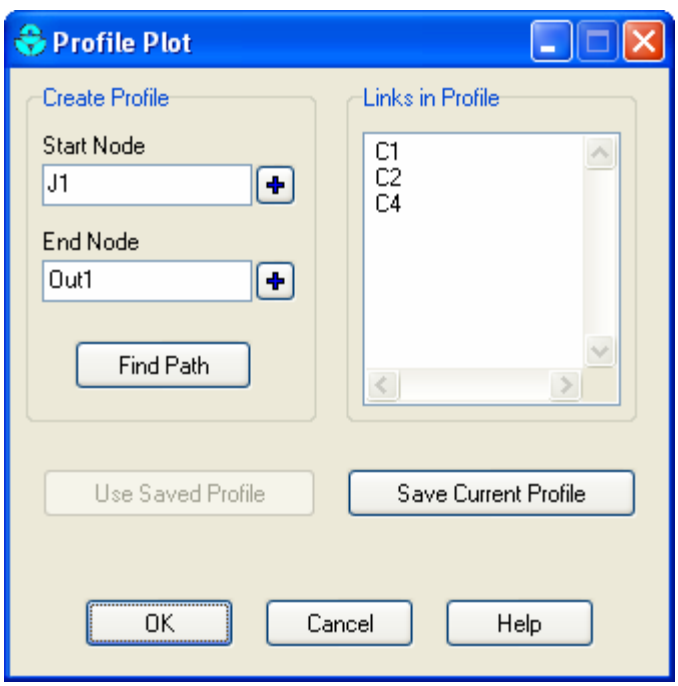

Figure 2-16. Profile Plot dialog.

3. Do the same for node **Out1** in the End Node field of the dialog.
4. Click the **Find Path** button. An ordered list of the links forming a connected path between the specified Start and End nodes will be displayed in the Links in Profile box. You can edit the entries in this box if need be.
5. Click the **OK** button to create the plot, showing the water surface profile as it exists at the simulation time currently selected in the Map Browser (see Figure 2-17).

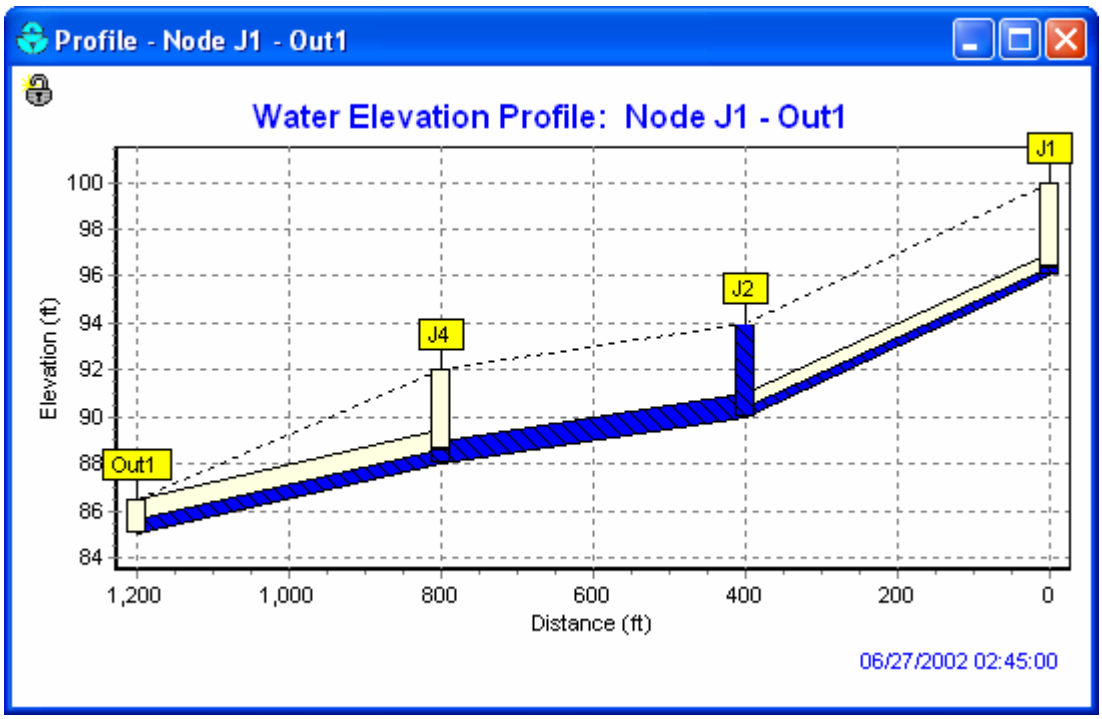

Figure 2-17. Example of a Profile plot.

As you move through time using the Map Browser or with the Animator control, the water depth profile on the plot will be updated. Observe how node **J2** becomes flooded between hours 2 and 3 of the storm event. A Profile Plot's appearance can be customized and it can be copied or printed using the same procedures as for a Time Series Plot.

Running a Full Dynamic Wave Analysis

In the analysis just run we chose to use the Kinematic Wave method of routing flows through our drainage system. This is an efficient but simplified approach that cannot deal with such phenomena as backwater effects, pressurized flow, flow reversal, and non-dendritic layouts. SWMM also includes a Dynamic Wave routing procedure that can represent these conditions. This procedure, however, requires more computation time, due to the need for smaller time steps to maintain numerical stability.

Most of the effects mentioned above would not apply to our example. However we had one conduit, **C2**, which flowed full and caused its upstream junction to flood. It could be

that this pipe is actually being pressurized and could therefore convey more flow than was computed using Kinematic Wave routing. We would now like to see what would happen if we apply Dynamic Wave routing instead.

To run the analysis with Dynamic Wave routing:

1. From the Data Browser, select the **Options** category and click the button.
2. On the General page of the Simulation Options dialog that appears, select Dynamic Wave as the flow routing method.
3. On the Dynamic Wave page of the dialog, use the settings shown in Figure 2-18[10].
4. Click **OK** to close the form and select **Project >> Run Simulation** (or click the button) to re-run the analysis.

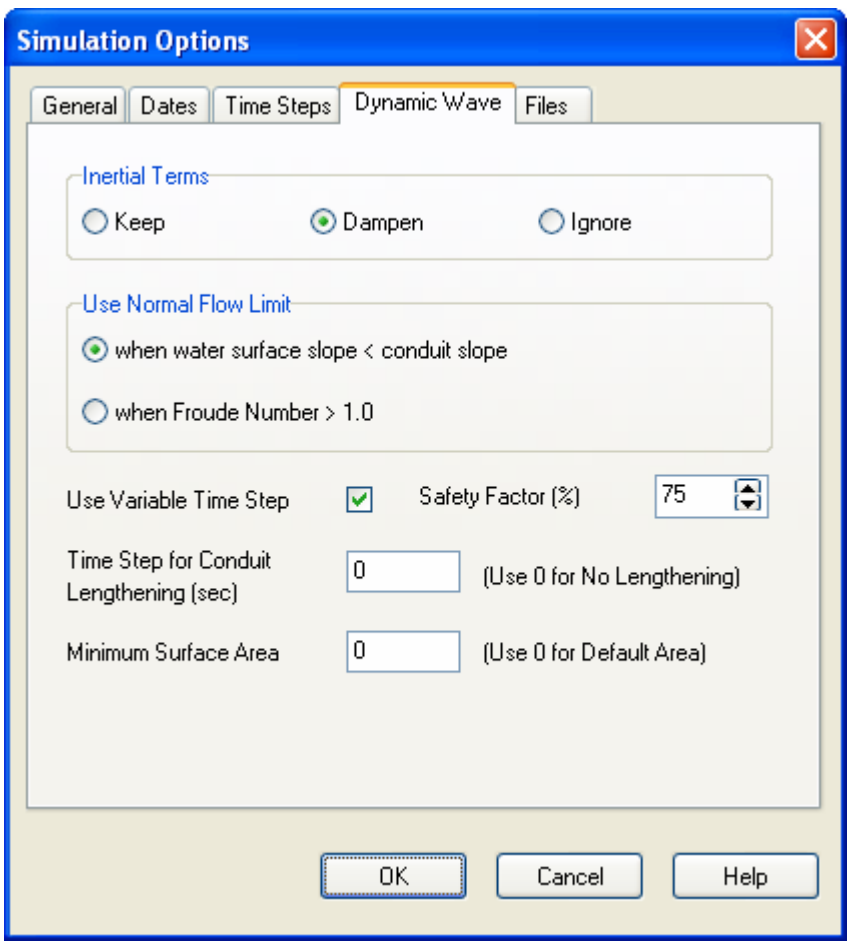

Figure 2-18. Dynamic Wave simulation options.

[10] Normally when running a Dynamic Wave analysis, one would also want to reduce the routing time step (on the Time Steps page of the dialog). In this example, we will continue to use a 1-minute time step.

If you look at the Status Report for this run, you will see that there is no longer any junction flooding and that the peak flow carried by conduit **C2** has been increased from 3.44 cfs to 4.04 cfs.

2.6 Simulating Water Quality

In the next phase of this tutorial we will add water quality analysis to our example project. SWMM has the ability to analyze the buildup, washoff, transport and treatment of any number of water quality constituents. The steps needed to accomplish this are:

1. Identify the pollutants to be analyzed.
2. Define the categories of land uses that generate these pollutants.
3. Set the parameters of buildup and washoff functions that determine the quality of runoff from each land use.
4. Assign a mixture of land uses to each subcatchment area
5. Define pollutant removal functions for nodes within the drainage system that contain treatment facilities.

We will now apply each of these steps, with the exception of number 5, to our example project[11].

We will define two runoff pollutants; total suspended solids (TSS), measured as mg/L, and total Lead, measured in ug/L. In addition, we will specify that the concentration of Lead in runoff is a fixed fraction (0.25) of the TSS concentration. To add these pollutants to our project:

1. Under the **Quality** category in the Data Browser, select the **Pollutants** sub-category beneath it.
2. Click the ✚ button to add a new pollutant to the project.
3. In the Pollutant Editor dialog that appears (see Figure 2-19), enter **TSS** for the pollutant name and leave the other data fields at their default settings.
4. Click the **OK** button to close the Editor.
5. Click the ✚ button on the Data Browser again to add our next pollutant.
6. In the Pollutant Editor, enter **Lead** for the pollutant name, select **ug/L** for the concentration units, enter **TSS** as the name of the Co-Pollutant, and enter **0.25** as the Co-Fraction value.
7. Click the **OK** button to close the Editor.

In SWMM, pollutants associated with runoff are generated by specific land uses assigned to subcatchments. In our example, we will define two categories of land uses: Residential and Undeveloped. To add these land uses to the project:

[11] Aside from surface runoff, SWMM allows pollutants to be introduced into the nodes of a drainage system through user-defined time series of direct inflows, dry weather inflows, groundwater interflow, and rainfall dependent inflow/infiltration

1. Under the **Quality** category in the Data Browser, select the **Land Uses** sub-category and click the ✚ button.
2. In the Land Use Editor dialog that appears (see Figure 2-20), enter **Residential** in the Name field and then click the **OK** button.
3. Repeat steps 1 and 2 to create the **Undeveloped** land use category.

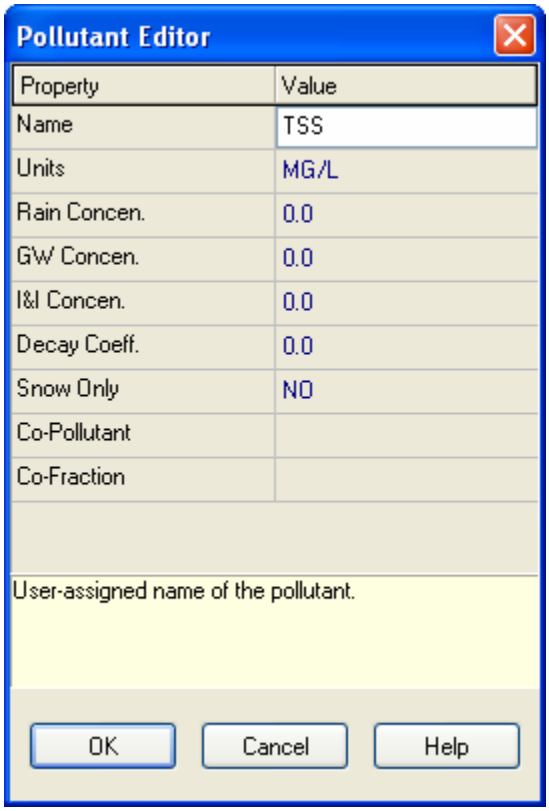

Figure 2-19. Pollutant Editor dialog.

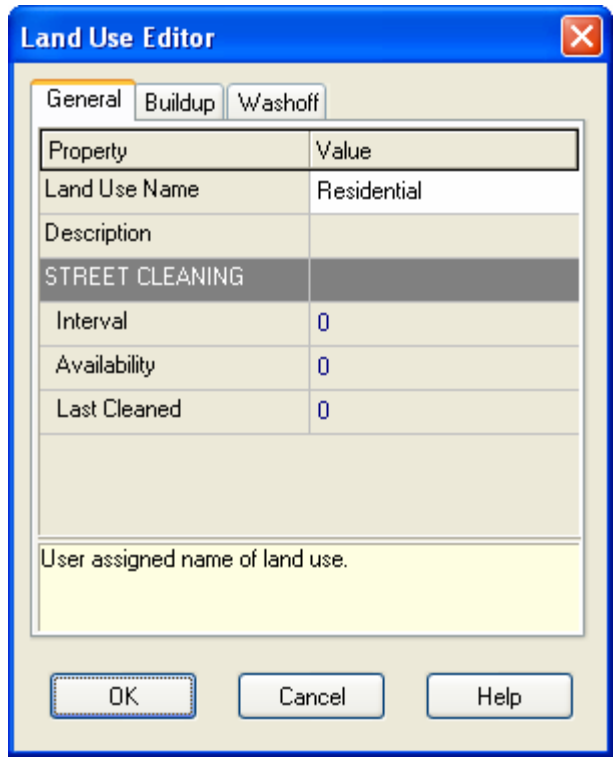

Figure 2-20. Land Use Editor dialog.

Next we need to define buildup and washoff functions for TSS in each of our land use categories. Functions for Lead are not needed since its runoff concentration was defined to be a fixed fraction of the TSS concentration. Normally, defining these functions requires site-specific calibration.

In this example we will assume that suspended solids in Residential areas builds up at a constant rate of 1 pound per acre per day until a limit of 50 lbs per acre is reached. For the Undeveloped area we will assume that buildup is only half as much. For the washoff function, we will assume a constant event mean concentration of 100 mg/L for Residential land and 50 mg/L for Undeveloped land. When runoff occurs, these concentrations will be maintained until the avaliable buildup is exhausted. To define these functions for the Residential land use:

1. Select the **Residential** land use category from the Data Browser and click the button.
2. In the Land Use Editor dialog, move to the Buildup page (see Figure 2-21).
3. Select **TSS** as the pollutant and **POW** (for Power function) as the function type.
4. Assign the function a maximum buildup of **50**, a rate constant of **1.0**, a power of **1** and select **AREA** as the normalizer.
5. Move to the Washoff page of the dialog and select **TSS** as the pollutant, **EMC** as the function type, and enter **100** for the coefficient. Fill the other fields with **0**.
6. Click the **OK** button to accept your entries.

Now do the same for the Undeveloped land use category, except use a maximum buildup of **25**, a buildup rate constant of **0.5**, a buildup power of **1**, and a washoff **EMC** of **50**.

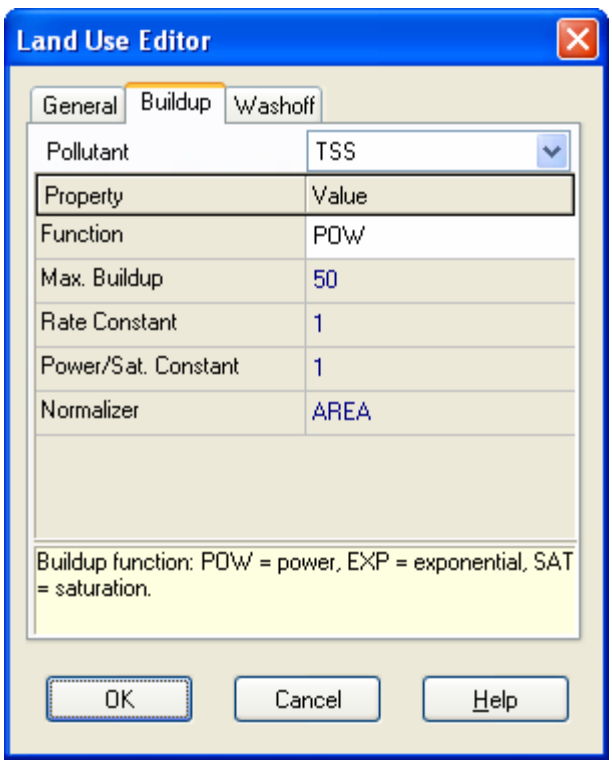

Figure 2-21. Defining a TSS buildup function for Residential land use.

The final step in our water quality example is to assign a mixture of land uses to each subcatchment area:

1. Select subcatchment **S1** into the Property Editor.
2. Select the Land Uses property and click the ellipsis button (or press <**Enter**>).
3. In the Land Use Assignment dialog that appears, enter **75** for the % Residential and **25** for the % Undeveloped (see Figure 2-22). Then click the **OK** button to close the dialog.

4. Repeat the same three steps for subcatchment **S2**.
5. Repeat the same for subcatchment **S3**, except assign the land uses as **25**% Residential and **75**% Undeveloped.

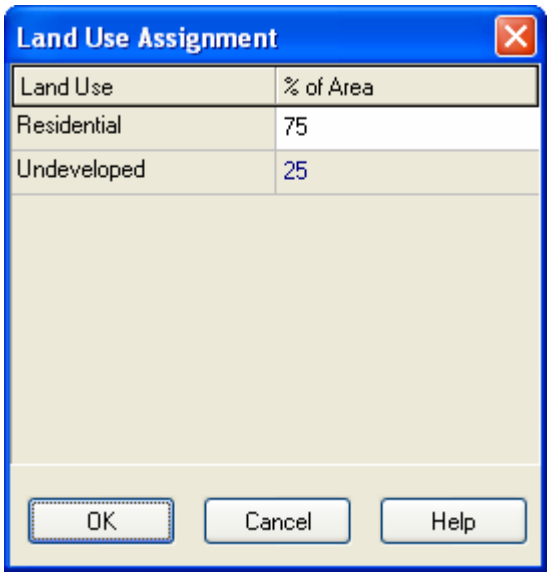

Figure 2-22. Land Use Assignment dialog.

Before we simulate the runoff quantities of TSS and Lead from our study area, an initial buildup of TSS should be defined so it can be washed off during our single rainfall event. We can either specify the number of antecedent dry days prior to the simulation or directly specify the initial buildup mass on each subcatchment. We will use the former method:

1. From the **Options** category of the Data Browser, select the **Dates** sub-category and click the button.
2. In the Simulation Options dialog that appears, enter **5** into the Antecedent Dry Days field.
3. Leave the other simulation options the same as they were for the dynamic wave flow routing we just completed.
4. Click the **OK** button to close the dialog.

Now run the simulation by selecting **Project >> Run Simulation** or by clicking on the Standard Toolbar.

When the run is completed, view its Status Report. Note that two new sections have been added for Runoff Quality Continuity and Quality Routing Continuity. From the Runoff Quality Continuity table we see that there was an initial buildup of 47.5 lbs of TSS on the study area and an additional 1.9 lbs of buildup added during the dry periods of the simulation. Almost 48 lbs were washed off during the rainfall event. The quantity of Lead washed off is a fixed percentage (25% times 0.001 to convert from mg to ug) of the TSS as was specified.

If you plot the runoff concentration of TSS for subcatchment S1 and S3 together on the same time series graph, as in Figure 2-23, you will see the difference in concentrations resulting from the different mix of land uses in these two areas. You can also see that the duration over which pollutants are washed off is much shorter than the duration of the entire runoff hydrograph (i.e., 1 hour versus about 6 hours). This results from having exhausted the available buildup of TSS over this period of time.

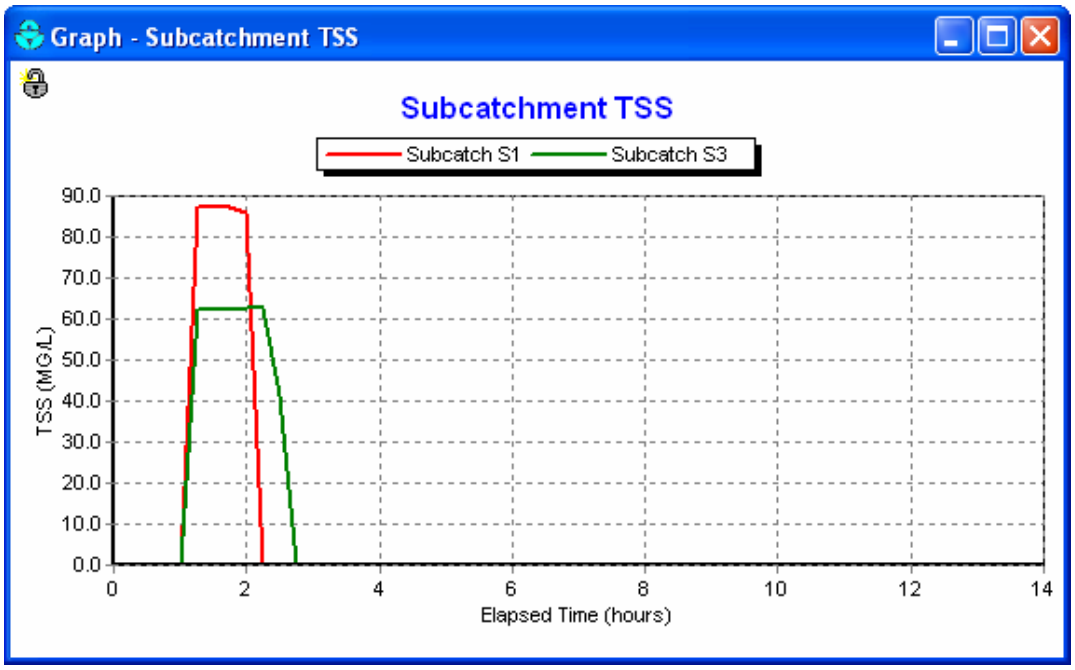

Figure 2-23. TSS concentration of runoff from selected subcatchments.

2.7 Running a Continuous Simulation

As a final exercise in this tutorial we will demonstrate how to run a long-term continuous simulation using a historical rainfall record and how to perform a statistical frequency analysis on the results. The rainfall record will come from a file named sta310301.dat that was included with the example data sets provided with EPA SWMM. It contains several years of hourly rainfall beginning in January 1998. The data are stored in the National Climatic Data Center's DSI 3240 format, which SWMM can automatically recognize.

To run a continuous simulation with this rainfall record:

1. Select the rain gage **Gage1** into the Property Editor.
2. Change the selection of Data Source to **FILE**.
3. Select the File Name data field and click the ellipsis button (or press the <Enter> key) to bring up a standard Windows File Selection dialog.
4. Navigate to the folder where the SWMM example files were stored, select the file named **sta310301.dat**, and click **Open** to select the file and close the dialog.

5. In the Station No. field of the Property Editor enter **310301**.
6. Select the **Options** category in the Data Browser and click the button to bring up the Simulation Options form.
7. On the General page of the form, select **Kinematic Wave** as the Routing Method (this will help speed up the computations).
8. On the Date page of the form, set both the Start Analysis and Start Reporting dates to **01/01/1998**, and set the End Analysis date to **01/01/2000**.
9. On the Time Steps page of the form, set the Routing Time Step to **00:05:00**.
10. Close the Simulation Options form by clicking the **OK** button and start the simulation by selecting **Project >> Run Simulation** (or by clicking on the Standard Toolbar).

After our continuous simulation is completed we can perform a statistical frequency analysis on any of the variables produced as output. For example, to determine the distribution of rainfall volumes within each storm event over the two-year period simulated:

1. Select **Report >> Statistics** or click the button on the Standard Toolbar.
2. In the Statistics Selection dialog that appears, enter the values shown in Figure 2-24.
3. Click the **OK** button to close the form.

The results of this request will be a Statistics Report form (see Figure 2-25) containing three tabbed pages: a Summary page, an Events page containing a rank-ordered listing of each event, and a Histogram page containing a plot of the occurrence frequency versus event magnitude.

The summary page shows that there were a total of 213 rainfall events. The Events page shows that the largest rainfall event had a volume of 3.35 inches and occurred over a 24-hour period. There were no events that matched the 3-inch, 6-hour design storm event used in our previous single-event analysis that had produced some internal flooding. In fact, the status report for this continuous simulation indicates that there were no flooding or surcharge occurrences over the simulation period.

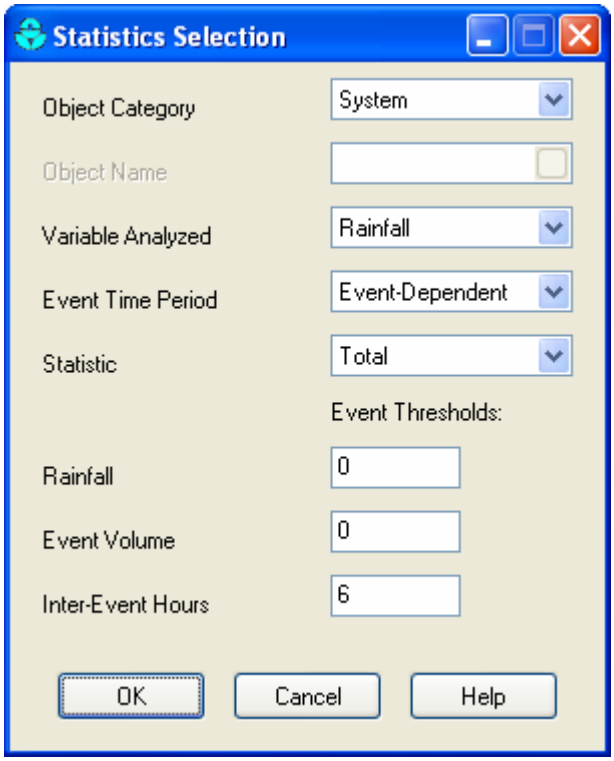

Figure 2-24. Statistics Selection dialog.

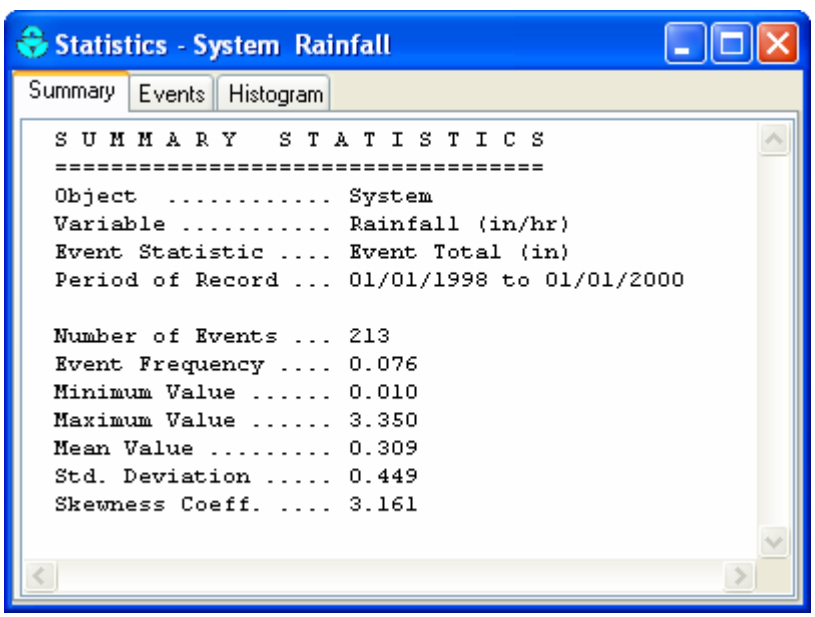

Figure 2-25. Statistical Analysis report.

We have only touched the surface of SWMM's capabilities. Some additional features of the program that you will find useful include:

- utilizing additional types of drainage elements, such as storage units, flow dividers, pumps, and regulators, to model more complex types of systems
- using control rules to simulate real-time operation of pumps and regulators
- employing different types of externally-imposed inflows at drainage system nodes, such as direct time series inflows, dry weather inflows, and rainfall-derived infiltration/inflow
- modeling groundwater interflow between aquifers beneath subcatchment areas and drainage system nodes
- modeling snow fall accumulation and melting within subcatchments
- adding calibration data to a project so that simulated results can be compared with measured values
- utilizing a background street, site plan, or topo map to assist in laying out a system's drainage elements and to help relate simulated results to real-world locations.

You can find more information on these and other features in the remaining chapters of this manual.

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CHAPTER 3 - SWMM's CONCEPTUAL MODEL

This chapter discusses how SWMM models the objects and operational parameters that constitute a stormwater drainage system. Details about how this information is entered into the program are presented in later chapters. An overview is also given on the computational methods that SWMM uses to simulate the hydrology, hydraulics and water quality transport behavior of a drainage system.

3.1 Introduction

SWMM conceptualizes a drainage system as a series of water and material flows between several major environmental compartments. These compartments and the SWMM objects they contain include:

- The Atmosphere compartment, from which precipitation falls and pollutants are deposited onto the land surface compartment. SWMM uses **Rain Gage** objects to represent rainfall inputs to the system.
- The Land Surface compartment, which is represented through one or more **Subcatchment** objects. It receives precipitation from the Atmospheric compartment in the form of rain or snow; it sends outflow in the form of infiltration to the Groundwater compartment and also as surface runoff and pollutant loadings to the Transport compartment.
- The Groundwater compartment receives infiltration from the Land Surface compartment and transfers a portion of this inflow to the Transport compartment. This compartment is modeled using **Aquifer** objects.
- The Transport compartment contains a network of conveyance elements (channels, pipes, pumps, and regulators) and storage/treatment units that transport water to outfalls or to treatment facilities. Inflows to this compartment can come from surface runoff, groundwater interflow, sanitary dry weather flow, or from user-defined hydrographs. The components of the Transport compartment are modeled with **Node** and **Link** objects

Not all compartments need appear in a particular SWMM model. For example, one could model just the transport compartment, using pre-defined hydrographs as inputs.

3.2 Visual Objects

Figure 3-1 depicts how a collection of SWMM's visual objects might be arranged together to represent a stormwater drainage system. These objects can be displayed on a map in the SWMM workspace. The following sections describe each of these objects.

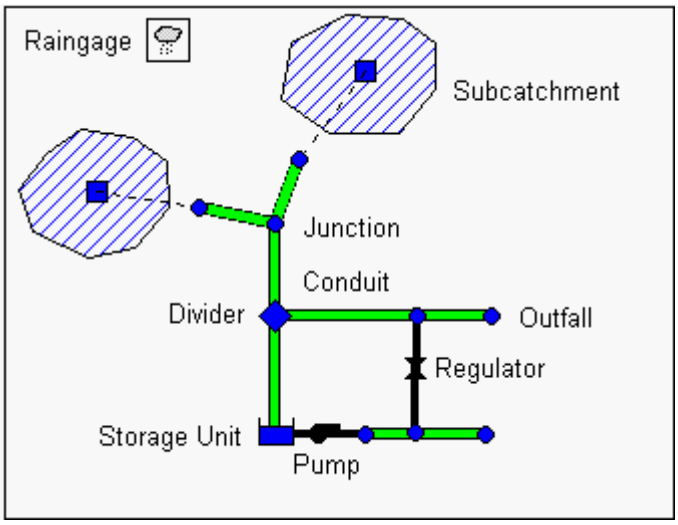


Figure 3-1. Example of physical objects used to model a drainage system.

3.2.1 Rain Gages

Rain Gages supply precipitation data for one or more subcatchment areas in a study region. The rainfall data can be either a user-defined time series or come from an external file. Several different popular rainfall file formats currently in use are supported, as well as a standard user-defined format.

The principal input properties of rain gages include:

- rainfall data type (e.g., intensity, volume, or cumulative volume)
- recording time interval (e.g., hourly, 15-minute, etc.)
- source of rainfall data (input time series or external file)
- name of rainfall data source

3.2.2 Subcatchments

Subcatchments are hydrologic units of land whose topography and drainage system elements direct surface runoff to a single discharge point. The user is responsible for dividing a study area into an appropriate number of subcatchments, and for identifying the outlet point of each subcatchment. Discharge outlet points can be either nodes of the drainage system or other subcatchments.

Subcatchments can be divided into pervious and impervious subareas. Surface runoff can infiltrate into the upper soil zone of the pervious subarea, but not through the impervious subarea. Impervious areas are themselves divided into two subareas - one that contains depression storage and another that does not. Runoff flow from one subarea in a subcatchment can be routed to the other subarea, or both subareas can drain to the subcatchment outlet.

Infiltration of rainfall from the pervious area of a subcatchment into the unsaturated upper soil zone can be described using three different models:

- Horton infiltration
- Green-Ampt infiltration
- SCS Curve Number infiltration

To model the accumulation, re-distribution, and melting of precipitation that falls as snow on a subcatchment, it must be assigned a Snow Pack object. To model groundwater flow between an aquifer underneath the subcatchment and a node of the drainage system, the subcatchment must be assigned a set of Groundwater parameters. Pollutant buildup and washoff from subcatchments are associated with the Land Uses assigned to the subcatchment.

The other principal input parameters for subcatchments include:

- assigned rain gage
- outlet node or subcatchment
- assigned land uses
- tributary surface area
- imperviousness
- slope
- characteristic width of overland flow
- Manning's n for overland flow on both pervious and impervious areas
- depression storage in both pervious and impervious areas
- percent of impervious area with no depression storage.

3.2.3 Junction Nodes

Junctions are drainage system nodes where links join together. Physically they can represent the confluence of natural surface channels, manholes in a sewer system, or pipe connection fittings. External inflows can enter the system at junctions. Excess water at a junction can become partially pressurized while connecting conduits are surcharged and can either be lost from the system or be allowed to pond atop the junction and subsequently drain back into the junction.

The principal input parameters for a junction are:

- invert elevation
- height to ground surface
- ponded surface area when flooded (optional)
- external inflow data (optional).

3.2.4 Outfall Nodes

Outfalls are terminal nodes of the drainage system used to define final downstream boundaries under Dynamic Wave flow routing. For other types of flow routing they behave as a junction. Only a single link can be connected to an outfall node.

The boundary conditions at an outfall can be described by any one of the following stage relationships:

- the critical or normal flow depth in the connecting conduit
- a fixed stage elevation
- a tidal stage described in a table of tide height versus hour of the day
- a user-defined time series of stage versus time.

The principal input parameters for outfalls include:

- invert elevation
- boundary condition type and stage description
- presence of a flap gate to prevent backflow through the outfall.

3.2.5 Flow Divider Nodes

Flow Dividers are drainage system nodes that divert inflows to a specific conduit in a prescribed manner. A flow divider can have no more than two conduit links on its discharge side. Flow dividers are only active under Kinematic Wave routing and are treated as simple junctions under Dynamic Wave routing.

There are four types of flow dividers, defined by the manner in which inflows are diverted:

Cutoff Divider:	diverts all inflow above a defined cutoff value.
Overflow Divider:	diverts all inflow above the flow capacity of the non-diverted conduit.
Tabular Divider:	uses a table that expresses diverted flow as a function of total inflow.
Weir Divider:	uses a weir equation to compute diverted flow.

The flow diverted through a weir divider is computed by the following equation

$$Q_{div} = C_w (fH_w)^{1.5}$$

where Q_{div} = diverted flow, C_w = weir coefficient, H_w = weir height and f is computed as

$$f = \frac{Q_{in} - Q_{\min}}{Q_{\max} - Q_{\min}}$$

where Q_{in} is the inflow to the divider, Q_{min} is the flow at which diversion begins, and $Q_{\max} = C_w H_w^{1.5}$. The user-specified parameters for the weir divider are Q_{min}, H_w, and C_w.

The principal input parameters for a flow divider are:

- junction parameters (see above)
- name of the link receiving the diverted flow
- method used for computing the amount of diverted flow.

3.2.6 Storage Units

Storage Units are drainage system nodes that provide storage volume. Physically they could represent storage facilities as small as a catchbasin or as large as a lake. The volumetric properties of a storage unit are described by a function or table of surface area versus height.

The principal input parameters for storage units include:

- invert elevation
- maximum depth
- depth-surface area data
- evaporation potential
- ponded surface area when flooded (optional)
- external inflow data (optional).

3.2.7 Conduits

Conduits are pipes or channels that move water from one node to another in the conveyance system. Their cross-sectional shapes can be selected from a variety of standard open and closed geometries as listed in Table 3-1. Irregular natural cross-section shapes are also supported.

SWMM uses the Manning equation to express the relationship between flow rate (Q), cross-sectional area (A), hydraulic radius (R), and slope (S) in open channels and partially full closed conduits. For standard U.S. units,

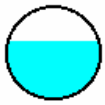
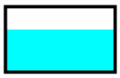
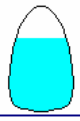
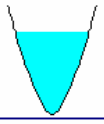
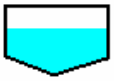
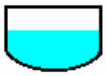
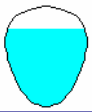
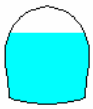
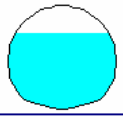
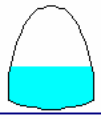
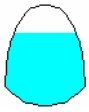
$$Q = \frac{1.49}{n} A R^{2/3} \sqrt{S}$$

where n is the Manning roughness coefficient. For Steady Flow and Kinematic Wave flow routing, S is interpreted as the conduit slope. For Dynamic Wave flow routing it is the friction slope (i.e., head loss per unit length).

The principal input parameters for conduits are:

- names of the inlet and outlet nodes
- offset heights of the conduit above the inlet and outlet node inverts
- conduit length
- Manning's roughness
- cross-sectional geometry
- entrance/exit losses
- presence of a flap gate to prevent reverse flow.

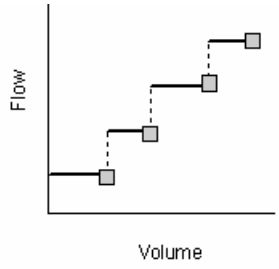
Table 3-1. Available cross section shapes for conduits

Name	Parameters	Shape	Name	Parameters	Shape
Circular	Depth		Filled Circular	Depth, Filled Depth	
Rectangular - Closed	Depth, Width		Rectangular – Open	Depth, Width	
Trapezoidal	Depth, Base Width, Side Slopes		Triangular	Depth, Top Width	
Horizontal Ellipse	Depth, Max Width		Vertical Ellipse	Depth, Max Width	
Arch	Depth, Max Width		Parabolic	Depth, Top Width	
Power	Depth, Top Width, Exponent		Rectangular-Triangular	Depth, Top Width, Triangle Height	
Rectangular-Round	Depth, Width		Modified Baskethandle	Depth, Bottom Width	
Egg	Depth		Horseshoe	Depth	
Gothic	Depth		Catenary	Depth	
Semi-Elliptical	Depth		Baskethandle	Depth	
Semi-Circular	Depth				

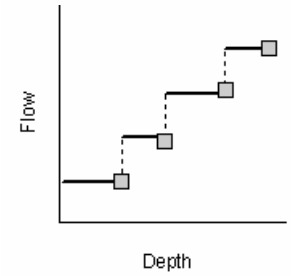
3.2.8 Pumps

Pumps are links used to lift water to higher elevations. A pump curve describes the relation between a pump's flow rate and conditions at its inlet and outlet nodes. Four different types of pump curves are supported:

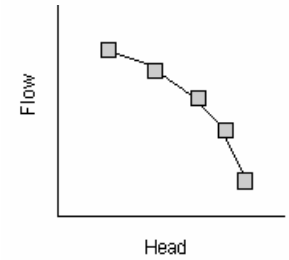
Type1
an off-line pump with a wet well where flow increases incrementally with available wet well volume



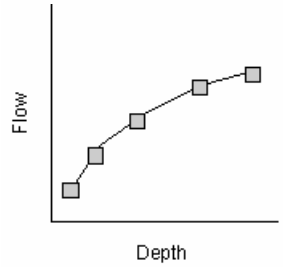
Type2
an in-line pump where flow increases incrementally with inlet node depth



Type3
an in-line pump where flow varies continuously with head difference between the inlet and outlet nodes



Type4
a variable speed in-line pump where flow varies continuously with inlet node depth



The on/off status of pumps can be controlled dynamically through user-defined Control Rules.

The principal input parameters for a pump include:

- names of its inlet and outlet nodes
- name of its pump curve
- initial on/off status.

3.2.9 Flow Regulators

Flow Regulators are structures or devices used to control and divert flows within a conveyance system. They are typically used to:

- control releases from storage facilities
- prevent unacceptable surcharging
- divert flow to treatment facilities and interceptors

SWMM can model the following types of flow regulators:

- Orifices
- Weirs
- Outlets.

Orifices

Orifices are used to model outlet and diversion structures in drainage systems, which are typically openings in the wall of a manhole, storage facility, or control gate. They are internally represented in SWMM as a link connecting two nodes. An orifice can have either a circular or rectangular shape, be located either at the bottom or along the side of the upstream node, and have a flap gate to prevent backflow.

Orifices can be used as storage unit outlets under all types of flow routing. If not attached to a storage unit node, they can only be used in drainage networks that are analyzed with Dynamic Wave flow routing.

The flow through a fully submerged orifice is computed as

$$Q = CA\sqrt{2gh}$$

where Q = flow rate, C = discharge coefficient, A = area of orifice opening, g = acceleration of gravity, and h = head difference across the orifice. The area of an orifice's opening can be controlled dynamically through user-defined Control Rules.

The principal input parameters for an orifice include:

- names of its inlet and outlet nodes
- configuration (bottom or side)
- shape (circular or rectangular)
- height above the inlet node invert
- discharge coefficient.

Weirs

Weirs, like orifices, are used to model outlet and diversion structures in a drainage system. Weirs are typically located in a manhole, along the side of a channel, or within a storage unit. They are internally represented in SWMM as a link connecting two nodes, where the weir itself is placed at the upstream node. A flap gate can be included to prevent backflow.

Four varieties of weirs are available, each incorporating a different formula for computing flow across the weir as listed in Table 3-2.

Table 3-2. Available types of weirs.

Weir Type	Cross Section Shape	Flow Formula
Transverse	Rectangular	$C_w L h^{3/2}$
Side flow	Rectangular	$C_w L h^{5/3}$
V-notch	Triangular	$C_w S h^{5/2}$
Trapezoidal	Trapezoidal	$C_w L h^{3/2} + C_{ws} S h^{5/2}$
C_w = weir discharge coefficient, L = weir length, S = side slope of V-notch or trapezoidal weir, h = head difference across the weir, C_{ws} = discharge coefficient through sides of trapezoidal weir.		

Weirs can be used as storage unit outlets under all types of flow routing. If not attached to a storage unit, they can only be used in drainage networks that are analyzed with Dynamic Wave flow routing.

The height of the weir crest above the inlet node invert can be controlled dynamically through user-defined Control Rules. This feature can be used to model inflatable dams.

The principal input parameters for a weir include:

- names of its inlet and outlet nodes
- shape and geometry
- crest height above the inlet node invert
- discharge coefficient.

Outlets

Outlets are flow control devices that are typically used to control outflows from storage units. They are used to model special head-discharge relationships that cannot be characterized by pumps, orifices, or weirs. Outlets are internally represented in SWMM as a link connecting two nodes. An outlet can also have a flap gate that restricts flow to only one direction.

Outlets attached to storage units are active under all types of flow routing. If not attached to a storage unit, they can only be used in drainage networks analyzed with Dynamic Wave flow routing.

A user-defined function or table of flow versus head difference determines the flow through an outlet.

The principal input parameters for an outlet include:

- names of its inlet and outlet nodes
- height above the inlet node invert
- function or table containing its head-discharge relationship.

3.2.10 Map Labels

Map Labels are optional text labels added to SWMM's Study Area Map to help identify particular objects or regions of the map. The labels can be drawn in any Windows font, freely edited and be dragged to any position on the map.

3.3 Non-Visual Objects

In addition to physical objects that can be displayed visually on a map, SWMM utilizes several classes of non-visual data objects to describe additional characteristics and processes within a study area.

3.3.1 Climatology

Temperature

Air temperature data are used when simulating snowfall and snowmelt processes during runoff calculations. If these processes are not being simulated then temperature data are not required. Air temperature data can be supplied to SWMM from one of the following sources:

- a user-defined time series of point values (values at intermediate times are interpolated)
- an external climate file containing daily minimum and maximum values (SWMM fits a sinusoidal curve through these values depending on the day of the year).

For user-defined time series, temperatures are in degrees F for US units and degrees C for metric units. The external climate file can also be used to supply evaporation and wind speed as well.

Evaporation

Evaporation can occur for standing water on subcatchment surfaces, for subsurface water in groundwater aquifers, and for water held in storage units. Evaporation rates can be stated as:

- a single constant value
- a set of monthly average values
- a user-defined time series of daily values
- daily values read from an external climate file.

If a climate file is used, then a set of monthly pan coefficients should also be supplied to convert the pan evaporation data to free water-surface values.

Wind Speed

Wind speed is an optional climatic variable that is only used for snowmelt calculations. SWMM can use either a set of monthly average speeds or wind speed data contained in the same climate file used for daily minimum/maximum temperatures.

Snowmelt

Snowmelt parameters are climatic variables that apply across the entire study area when simulating snowfall and snowmelt. They include:

- the air temperature at which precipitation falls as snow
- heat exchange properties of the snow surface
- study area elevation, latitude, and longitude correction

Areal Depletion

Areal depletion refers to the tendency of accumulated snow to melt non-uniformly over the surface of a subcatchment. As the melting process proceeds, the area covered by snow gets reduced. This behavior is described by an Areal Depletion Curve that plots the fraction of total area that remains snow covered against the ratio of the actual snow depth to the depth at which there is 100% snow cover. A typical ADC for a natural area is shown in Figure 3-2. Two such curves can be supplied to SWMM, one for impervious areas and another for pervious areas.

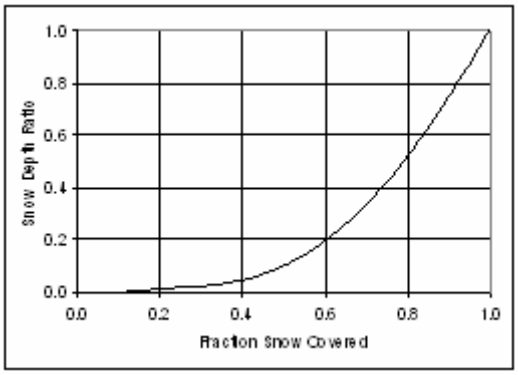


Figure 3-2. Areal Depletion curve for a natural area.

3.3.2 Snow Packs

Snow Pack objects contain parameters that characterize the buildup, removal, and melting of snow over three types of sub-areas within a subcatchment:

- The Plowable snow pack area consists of a user-defined fraction of the total impervious area. It is meant to represent such areas as streets and parking lots where plowing and snow removal can be done.
- The Impervious snow pack area covers the remaining impervious area of a subcatchment.
- The Pervious snow pack area encompasses the entire pervious area of a subcatchment.

Each of these three areas is characterized by the following parameters:

- Minimum and maximum snow melt coefficients
- minimum air temperature for snow melt to occur
- snow depth above which 100% areal coverage occurs
- initial snow depth
- initial and maximum free water content in the pack.

In addition, a set of snow removal parameters can be assigned to the Plowable area. These parameters consist of the depth at which snow removal begins and the fractions of snow moved onto various other areas.

Subcatchments are assigned a snow pack object through their Snow Pack property. A single snow pack object can be applied to any number of subcatchments. Assigning a snow pack to a subcatchment simply establishes the melt parameters and initial snow conditions for that subcatchment. Internally, SWMM creates a "physical" snow pack for each subcatchment, which tracks snow accumulation and melting for that particular subcatchment based on its snow pack parameters, its amount of pervious and impervious area, and the precipitation history it sees.

3.3.3 Aquifers

Aquifers are sub-surface groundwater areas used to model the vertical movement of water infiltrating from the subcatchments that lie above them. They also permit the infiltration of groundwater into the drainage system, or exfiltration of surface water from the drainage system, depending on the hydraulic gradient that exists. The same aquifer object can be shared by several subcatchments. Aquifers are only required in models that need to explicitly account for the exchange of groundwater with the drainage system or to establish baseflow and recession curves in natural channels and non-urban systems.

Aquifers are represented using two zones – an un-saturated zone and a saturated zone. Their behavior is characterized using such parameters as soil porosity, hydraulic conductivity, evapotranspiration depth, bottom elevation, and loss rate to deep groundwater. In addition, the initial water table elevation and initial moisture content of the unsaturated zone must be supplied.

Aquifers are connected to subcatchments and to drainage system nodes as defined in a subcatchment's Groundwater Flow property. This property also contains parameters that govern the rate of groundwater flow between the aquifer's saturated zone and the drainage system node.

3.3.4 Unit Hydrographs

Unit Hydrographs (UHs) estimate rainfall-derived infiltration/inflow (RDII) into a sewer system. A UH set contains up to three such hydrographs, one for a short-term response, one for an intermediate-term response, and one for a long-term response. A UH group can have up to 12 UH sets, one for each month of the year. Each UH group is considered as a separate object by SWMM, and is assigned its own unique name along with the name of the rain gage that supplies rainfall data to it.

Each unit hydrograph, as shown in Figure 3-3, is defined by three parameters:

- R: the fraction of rainfall volume that enters the sewer system
- T: the time from the onset of rainfall to the peak of the UH in hours
- K: the ratio of time to recession of the UH to the time to peak

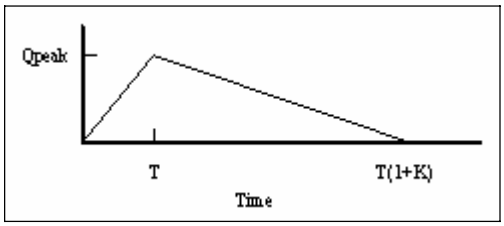


Figure 3-3. An RDII unit hydrograph

To generate RDII into a drainage system node, the node must identify (through its Inflows property) the UH group and the area of the surrounding sewershed that contributes RDII flow.

An alternative to using unit hydrographs to define RDII flow is to create an external RDII interface file, which contains RDII time series data.

3.3.5 Transects

Transects refer to the geometric data that describe how bottom elevation varies with horizontal distance over the cross section of a natural channel or irregular-shaped conduit. Figure 3-4 displays an example of a transect for a natural channel.

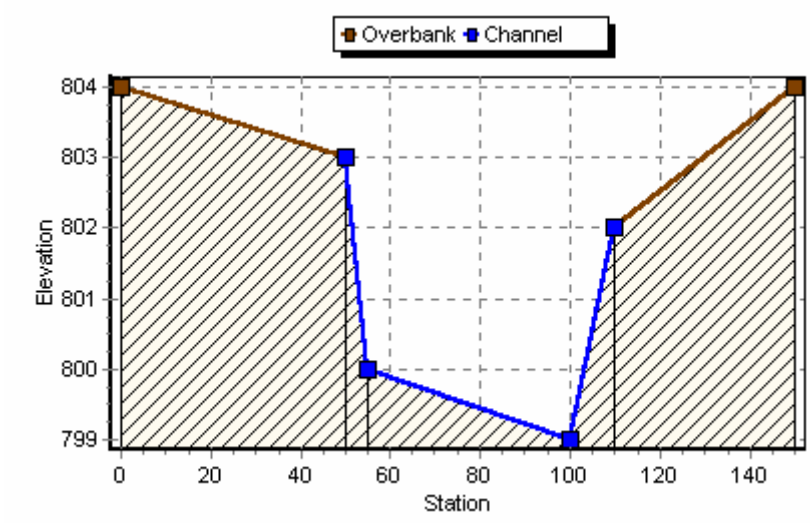


Figure 3-4. Example of a natural channel transect.

Each transect must be given a unique name. Conduits refer to that name to represent their shape. A special Transect Editor is available for editing the station-elevation data of a transect. SWMM internally converts these data into tables of area, top width, and hydraulic radius versus channel depth. In addition, as shown in the diagram above, each transect can have a left and right overbank section whose Manning's roughness can be different from that of the main channel. This feature can provide more realistic estimates of channel conveyance under high flow conditions.

3.3.6 External Inflows

In addition to inflows originating from subcatchment runoff and groundwater, drainage system nodes can receive three other types of external inflows:

- Direct Inflows - These are user-defined time series of inflows added directly into a node. They can be used to perform flow and water quality routing in the absence of any runoff computations (as in a study area where no subcatchments are defined).
- Dry Weather Inflows - These are continuous inflows that typically reflect the contribution from sanitary sewage in sewer systems or base flows in pipes and stream channels. They are represented by an average inflow rate that can be periodically adjusted on a monthly, daily, and hourly basis by applying Time Pattern multipliers to this average value.
- Rainfall-Dependent Infiltration/Inflow (RDII) - These are stormwater flows that enter sanitary or combined sewers due to "inflow" from direct connections of downspouts, sump pumps, foundation drains, etc. as well as "infiltration" of subsurface water through cracked pipes, leaky joints, poor manhole connections, etc. RDII can be computed for a given rainfall record based on set of triangular unit hydrographs (UH) that determine a short-term, intermediate-term, and long-term inflow response for each time period of rainfall. Any number of UH sets can be supplied for different sewershed areas and different months of the year. RDII flows can also be specified in an external RDII interface file.

Direct, Dry Weather, and RDII inflows are properties associated with each type of drainage system node (junctions, outfalls, flow dividers, and storage units) and can be specified when nodes are edited. It is also possible to make the outflows generated from an upstream drainage system be the inflows to a downstream system by using interface files. See Section 11.7 for further details.

3.3.7 Control Rules

Control Rules determine how pumps and regulators in the drainage system will be adjusted over the course of a simulation. Some examples of these rules are:

Simple time-based pump control:

```
RULE R1
IF SIMULATION TIME > 8
THEN PUMP 12 STATUS = ON
ELSE PUMP 12 STATUS = OFF
```

Multiple-condition orifice gate control:

```
RULE R2A
IF NODE 23 DEPTH > 12
AND LINK 165 FLOW > 100
THEN ORIFICE R55 SETTING = 0.5

RULE R2B
IF NODE 23 DEPTH > 12
AND LINK 165 FLOW > 200
THEN ORIFICE R55 SETTING = 1.0

RULE R2C
IF NODE 23 DEPTH <= 12
OR LINK 165 FLOW <= 100
THEN ORIFICE R55 SETTING = 0
```

Pump station operation:

```
RULE R3A
IF NODE N1 DEPTH > 5
THEN PUMP N1A STATUS = ON

RULE R3B
IF NODE N1 DEPTH > 7
THEN PUMP N1B STATUS = ON

RULE R3C
IF NODE N1 DEPTH <= 3
THEN PUMP N1A STATUS = OFF
AND PUMP N1B STATUS = OFF
```

Appendix C.3 describes the control rule format in more detail and the special Editor used to edit them.

3.3.8 Pollutants

SWMM can simulate the generation, inflow and transport of any number of user-defined pollutants. Required information for each pollutant includes:

- pollutant name
- concentration units (i.e., milligrams/liter, micrograms/liter, or counts/liter)
- concentration in rainfall
- concentration in groundwater
- concentration in direct infiltration/inflow
- first-order decay coefficient.

Co-pollutants can also be defined in SWMM. For example, pollutant X can have a co-pollutant Y, meaning that the runoff concentration of X will have some fixed fraction of the runoff concentration of Y added to it.

Pollutant buildup and washoff from subcatchment areas are determined by the land uses assigned to those areas. Input loadings of pollutants to the drainage system can also originate from external time series inflows as well as from dry weather inflows.

3.3.9 Land Uses

Land Uses are categories of development activities or land surface characteristics assigned to subcatchments. Examples of land use activities are residential, commercial, industrial, and undeveloped. Land surface characteristics might include rooftops, lawns, paved roads, undisturbed soils, etc. Land uses are used solely to account for spatial variation in pollutant buildup and washoff rates within subcatchments.

The SWMM user has many options for defining land uses and assigning them to subcatchment areas. One approach is to assign a mix of land uses for each subcatchment, which results in all land uses within the subcatchment having the same pervious and impervious characteristics. Another approach is to create subcatchments that have a single land use classification along with a distinct set of pervious and impervious characteristics that reflects the classification.

The following processes can be defined for each land use category:

- pollutant buildup
- pollutant washoff
- street cleaning.

Pollutant Buildup

Pollutant buildup that accumulates within a land use category is described (or "normalized") by either a mass per unit of subcatchment area or per unit of curb length. Mass is expressed in pounds for US units and kilograms for metric units. The amount of buildup is a function of the number of preceding dry weather days and can be computed using one of the following functions:

- Power Function: Pollutant buildup (B) accumulates proportionally to time (t) raised to some power, until a maximum limit is achieved,

  $$B = Min(C_1, C_2 t^{C_3})$$

  where C_1 = maximum buildup possible (mass per unit of area or curb length), C_2 = buildup rate constant, and C_3 = time exponent.

- Exponential Function: Buildup follows an exponential growth curve that approaches a maximum limit asymptotically,

  $$B = C_1(1 - e^{-C_2 t})$$

  where C_1 = maximum buildup possible (mass per unit of area or curb length) and C_2 = buildup rate constant (1/days).

- Saturation Function: Buildup begins at a linear rate that continuously declines with time until a saturation value is reached,

$$B = \frac{C_1 t}{C_2 + t}$$

where C_1 = maximum buildup possible (mass per unit area or curb length) and C_2 = half-saturation constant (days to reach half of the maximum buildup).

Pollutant Washoff

Pollutant washoff from a given land use category occurs during wet weather periods and can be described in one of the following ways:

- Exponential Washoff: The washoff load (W) in units of mass per hour is proportional to the product of runoff raised to some power and to the amount of buildup remaining,

$$W = C_1 q^{C_2} B$$

where C_1 = washoff coefficient, C_2 = washoff exponent, q = runoff rate per unit area (inches/hour or mm/hour), and B = pollutant buildup in mass (lbs or kg) per unit area or curb length. Washoff mass units are the same as used to express the pollutant's concentration (milligrams, micrograms, or counts).

- Rating Curve Washoff: The rate of washoff W in mass per second is proportional to the runoff rate raised to some power,

$$W = C_1 Q^{C_2}$$

where C_1 = washoff coefficient, C_2 = washoff exponent, and Q = runoff rate in user-defined flow units.

- Event Mean Concentration: This is a special case of Rating Curve Washoff where the exponent is 1.0 and the coefficient C_1 represents the washoff pollutant concentration in mass per liter (Note: the conversion between user-defined flow units used for runoff and liters is handled internally by SWMM).

Note that in each case buildup is continuously depleted as washoff proceeds, and washoff ceases when there is no more buildup available.

Washoff loads for a given pollutant and land use category can be reduced by a fixed percentage by specifying a BMP Removal Efficiency that reflects the effectiveness of any BMP controls associated with the land use. It is also possible to use the Event Mean Concentration option by itself, without having to model any pollutant buildup at all.

Street Sweeping

Street sweeping can be used on each land use category to periodically reduce the accumulated buildup of specific pollutants. The parameters that describe street sweeping include:

- days between sweeping
- days since the last sweeping at the start of the simulation
- the fraction of buildup of all pollutants that is available for removal by sweeping
- the fraction of available buildup for each pollutant removed by sweeping

Note that these parameters can be different for each land use, and the last parameter can vary also with pollutant.

3.3.10 Treatment

Removal of pollutants from the flow streams entering any drainage system node is modeled by assigning a set of treatment functions to the node. A treatment function can be any well-formed mathematical expression involving:

- the pollutant concentration of the mixture of all flow streams entering the node (use the pollutant name to represent a concentration)
- the removals of other pollutants (use **R_** prefixed to the pollutant name to represent removal)
- any of the following process variables:
  - **FLOW** for flow rate into node (in user-defined flow units)
  - **DEPTH** for water depth above node invert (ft or m)
  - **AREA** for node surface area (ft2 or m2)
  - **DT** for routing time step (sec)
  - **HRT** for hydraulic residence time (hours)

The result of the treatment function can be either a concentration (denoted by the letter **C**) or a fractional removal (denoted by **R**). For example, a first-order decay expression for BOD exiting from a storage node might be expressed as:

```
C = BOD * exp(-0.05*HRT)
```

or the removal of some trace pollutant that is proportional to the removal of total suspended solids (TSS) could be expressed as:

```
R = 0.75 * R_TSS
```

3.3.11 Curves

Curve objects are used to describe a functional relationship between two quantities. The following types of curves are available in SWMM:

- Storage - describes how the surface area of a Storage Unit node varies with water depth.
- Diversion - relates diverted outflow to total inflow for a Flow Divider node.
- Tidal - describes how the stage at an Outfall node changes by hour of the day.
- Pump - relates flow through a Pump link to the depth or volume at the upstream node or to the head delivered by the pump.
- Rating - relates flow through an Outlet link to the head difference across the outlet.

Each curve must be given a unique name and can be assigned any number of data pairs.

3.3.12 Time Series

Time Series objects are used to describe how certain object properties vary with time. Time series can be used to describe:

- temperature data
- evaporation data
- rainfall data
- water stage at outfall nodes
- external inflow hydrographs at drainage system nodes
- external inflow pollutographs at drainage system nodes.

Each time series must be given a unique name and can be assigned any number of time-value data pairs. Time can be specified either as hours from the start of a simulation or as an absolute date and time-of-day.

For rainfall time series, it is only necessary to enter periods with non-zero rainfall amounts. SWMM interprets the rainfall value as a constant value lasting over the recording interval specified for the rain gage that utilizes the time series. For all other types of time series, SWMM uses interpolation to estimate values at times that fall in between the recorded values.

For times that fall outside the range of the time series, SWMM will use a value of 0 for rainfall and external inflow time series, and either the first or last series value for temperature, evaporation, and water stage time series.

3.3.13 Time Patterns

Time Patterns allow external Dry Weather Flow (DWF) to vary in a periodic fashion. They consist of a set of adjustment factors applied as multipliers to a baseline DWF flow rate or pollutant concentration. The different types of time patterns include:

- Monthly - one multiplier for each month of the year
- Daily - one multiplier for each day of the week
- Hourly - one multiplier for each hour from 12 AM to 11 PM

- Weekend - hourly multipliers for weekend days

Each Time Pattern must have a unique name and there is no limit on the number of patterns that can be created. Each dry weather inflow (either flow or quality) can have up to four patterns associated with it, one for each type listed above.

3.4 Computational Methods

SWMM is a physically based, discrete-time simulation model. It employs principles of conservation of mass, energy, and momentum wherever appropriate. This section briefly describes the methods SWMM uses to model stormwater runoff quantity and quality through the following physical processes:

- Surface Runoff
- Infiltration
- Groundwater
- Snow Melt
- Flow Routing
- Surface Ponding
- Water Quality Routing

3.4.1 Surface Runoff

The conceptual view of surface runoff used by SWMM is illustrated in Figure 3-5 below. Each subcatchment surface is treated as a nonlinear reservoir. Inflow comes from precipitation and any designated upstream subcatchments. There are several outflows, including infiltration, evaporation, and surface runoff. The capacity of this "reservoir" is the maximum depression storage, which is the maximum surface storage provided by ponding, surface wetting, and interception. Surface runoff per unit area, Q, occurs only when the depth of water in the "reservoir" exceeds the maximum depression storage, dp, in which case the outflow is given by Manning's equation. Depth of water over the subcatchment (d in feet) is continuously updated with time (t in seconds) by solving numerically a water balance equation over the subcatchment.

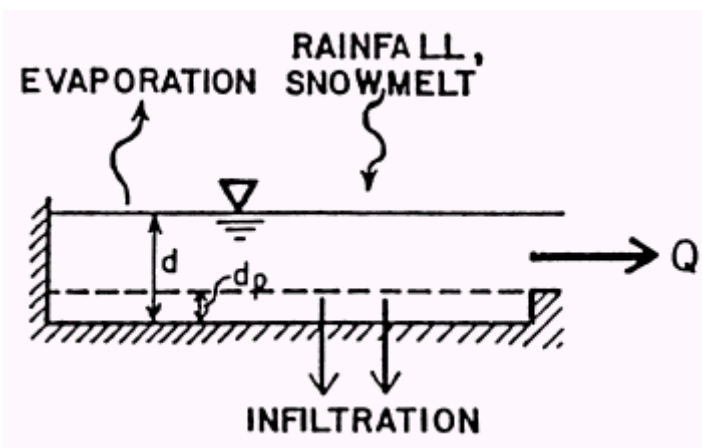


Figure 3-5. Conceptual view of surface runoff.

Infiltration

Infiltration is the process of rainfall penetrating the ground surface into the unsaturated soil zone of pervious subcatchments areas. SWMM offers three choices for modeling infiltration:

Horton's Equation
This method is based on empirical observations showing that infiltration decreases exponentially from an initial maximum rate to some minimum rate over the course of a long rainfall event. Input parameters required by this method include the maximum and minimum infiltration rates, a decay coefficient that describes how fast the rate decreases over time, and a time it takes a fully saturated soil to completely dry.

Green-Ampt Method
This method for modeling infiltration assumes that a sharp wetting front exists in the soil column, separating soil with some initial moisture content below from saturated soil above. The input parameters required are the initial moisture deficit of the soil, the soil's hydraulic conductivity, and the suction head at the wetting front.

Curve Number Method
This approach is adopted from the NRCS (SCS) Curve Number method for estimating runoff. It assumes that the total infiltration capacity of a soil can be found from the soil's tabulated Curve Number. During a rain event this capacity is depleted as a function of cumulative rainfall and remaining capacity. The input parameters for this method are the curve number, the soil's hydraulic conductivity (used to estimate a minimum separation time for distinct rain events), and a time it takes a fully saturated soil to completely dry.

3.4.2 Groundwater

Figure 3-6 is a definitional sketch of the two-zone groundwater model that is used in SWMM. The upper zone is unsaturated with a variable moisture content of θ. The lower zone is fully saturated and therefore its moisture content is fixed at the soil porosity ϕ. The fluxes shown in the figure, expressed as volume per unit area per unit time, consist of the following:

f_I infiltration from the surface

f_{EU} evapotranspiration from the upper zone which is a fixed fraction of the un-used surface evaporation

f_U percolation from the upper to lower zone which depends on the upper zone moisture content θ and depth d_U

f_{EL} evapotranspiration from the lower zone, which is a function of the depth of the upper zone d_U

f_L percolation from the lower zone to deep groundwater which depends on the lower zone depth d_L

f_G lateral groundwater interflow to the drainage system, which depends on the lower zone depth d_L as well as the depth in the receiving channel or node.

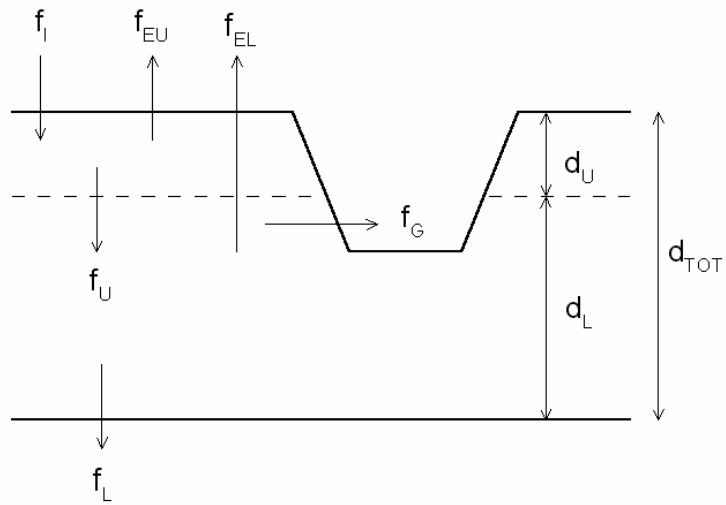


Figure 3-6. Two-zone groundwater model.

After computing the water fluxes that exist during a given time step, a mass balance is written for the change in water volume stored in each zone so that a new water table depth and unsaturated zone moisture content can be computed for the next time step.

3.4.3 Snowmelt

The snowmelt routine in SWMM is a part of the runoff modeling process. It updates the state of the snow packs associated with each subcatchment by accounting for snow accumulation, snow redistribution by areal depletion and removal operations, and snow melt via heat budget accounting. Any snowmelt coming off the pack is treated as an additional rainfall input onto the subcatchment.

At each runoff time step the following computations are made:

1. Air temperature and melt coefficients are updated according to the calendar date.
2. Any precipitation that falls as snow is added to the snow pack.
3. Any excess snow depth on the plowable area of the pack is redistributed according to the removal parameters established for the pack.
4. Areal coverages of snow on the impervious and pervious areas of the pack are reduced according to the Areal Depletion Curves defined for the study area.
5. The amount of snow in the pack that melts to liquid water is found using:
   - a heat budget equation for periods with rainfall, where melt rate increases with increasing air temperature, wind speed, and rainfall intensity
   - a degree-day equation for periods with no rainfall, where melt rate equals the product of a melt coefficient and the difference between the air temperature and the pack's base melt temperature.
6. If no melting occurs, the pack temperature is adjusted up or down based on the product of the difference between current and past air temperatures and an adjusted melt coefficient. If melting occurs, the temperature of the pack is increased by the

equivalent heat content of the melted snow, up to the base melt temperature. Any remaining melt liquid beyond this is available to runoff from the pack.

7. The available snowmelt is then reduced by the amount of free water holding capacity remaining in the pack. The remaining melt is treated the same as an additional rainfall input onto the subcatchment.

3.4.4 Flow Routing

Flow routing within a conduit link in SWMM is governed by the conservation of mass and momentum equations for gradually varied, unsteady flow (i.e., the Saint Venant flow equations). The SWMM user has a choice on the level of sophistication used to solve these equations:

- Steady Flow Routing
- Kinematic Wave Routing
- Dynamic Wave Routing

Steady Flow Routing

Steady Flow routing represents the simplest type of routing possible (actually no routing) by assuming that within each computational time step flow is uniform and steady. Thus it simply translates inflow hydrographs at the upstream end of the conduit to the downstream end, with no delay or change in shape. The Manning equation is used to relate flow rate to flow area (or depth).

This type of routing cannot account for channel storage, backwater effects, entrance/exit losses, flow reversal or pressurized flow. It can only be used with dendritic conveyance networks, where each node has only a single outflow link (unless the node is a divider in which case two outflow links are required). This form of routing is insensitive to the time step employed and is really only appropriate for preliminary analysis using long-term continuous simulations.

Kinematic Wave Routing

This routing method solves the continuity equation along with a simplified form of the momentum equation in each conduit. The latter requires that the slope of the water surface equal the slope of the conduit.

The maximum flow that can be conveyed through a conduit is the full-flow Manning equation value. Any flow in excess of this entering the inlet node is either lost from the system or can pond atop the inlet node and be re-introduced into the conduit as capacity becomes available.

Kinematic wave routing allows flow and area to vary both spatially and temporally within a conduit. This can result in attenuated and delayed outflow hydrographs as inflow is routed through the channel. However this form of routing cannot account for backwater effects, entrance/exit losses, flow reversal, or pressurized flow, and is also restricted to dendritic network layouts. It can usually maintain numerical stability with moderately large time steps, on the order of 5 to 15 minutes. If the aforementioned effects are not

expected to be significant then this alternative can be an accurate and efficient routing method, especially for long-term simulations.

Dynamic Wave Routing

Dynamic Wave routing solves the complete one-dimensional Saint Venant flow equations and therefore produces the most theoretically accurate results. These equations consist of the continuity and momentum equations for conduits and a volume continuity equation at nodes.

With this form of routing it is possible to represent pressurized flow when a closed conduit becomes full, such that flows can exceed the full-flow Manning equation value. Flooding occurs when the water depth at a node exceeds the maximum available depth, and the excess flow is either lost from the system or can pond atop the node and re-enter the drainage system.

Dynamic wave routing can account for channel storage, backwater, entrance/exit losses, flow reversal, and pressurized flow. Because it couples together the solution for both water levels at nodes and flow in conduits it can be applied to any general network layout, even those containing multiple downstream diversions and loops. It is the method of choice for systems subjected to significant backwater effects due to downstream flow restrictions and with flow regulation via weirs and orifices. This generality comes at a price of having to use much smaller time steps, on the order of a minute or less (SWMM will automatically reduce the user-defined maximum time step as needed to maintain numerical stability).

3.4.5 Surface Ponding

Normally in flow routing, when the flow into a junction exceeds the capacity of the system to transport it further downstream, the excess volume overflows the system and is lost. An option exists to have instead the excess volume be stored atop the junction, in a ponded fashion, and be reintroduced into the system as capacity permits. Under Steady and Kinematic Wave flow routing, the ponded water is stored simply as an excess volume. For Dynamic Wave routing, which is influenced by the water depths maintained at nodes, the excess volume is assumed to pond over the node with a constant surface area. This amount of surface area is an input parameter supplied for the junction.

Alternatively, the user may wish to represent the surface overflow system explicitly. In open channel systems this can include road overflows at bridges or culvert crossings as well as additional floodplain storage areas. In closed conduit systems, surface overflows may be conveyed down streets, alleys, or other surface routes to the next available stormwater inlet or open channel. Overflows may also be impounded in surface depressions such as parking lots, back yards or other areas.

3.4.6 Water Quality Routing

Water quality routing within conduit links assumes that the conduit behaves as a continuously stirred tank reactor (CSTR). Although a plug flow reactor assumption might be more realistic, the differences will be small if the travel time through the conduit is on the same order as the routing time step. The concentration of a constituent exiting the

conduit at the end of a time step is found by integrating the conservation of mass equation, using average values for quantities that might change over the time step such as flow rate and conduit volume.

Water quality modeling within storage unit nodes follows the same approach used for conduits. For other types of nodes that have no volume, the quality of water exiting the node is simply the mixture concentration of all water entering the node.

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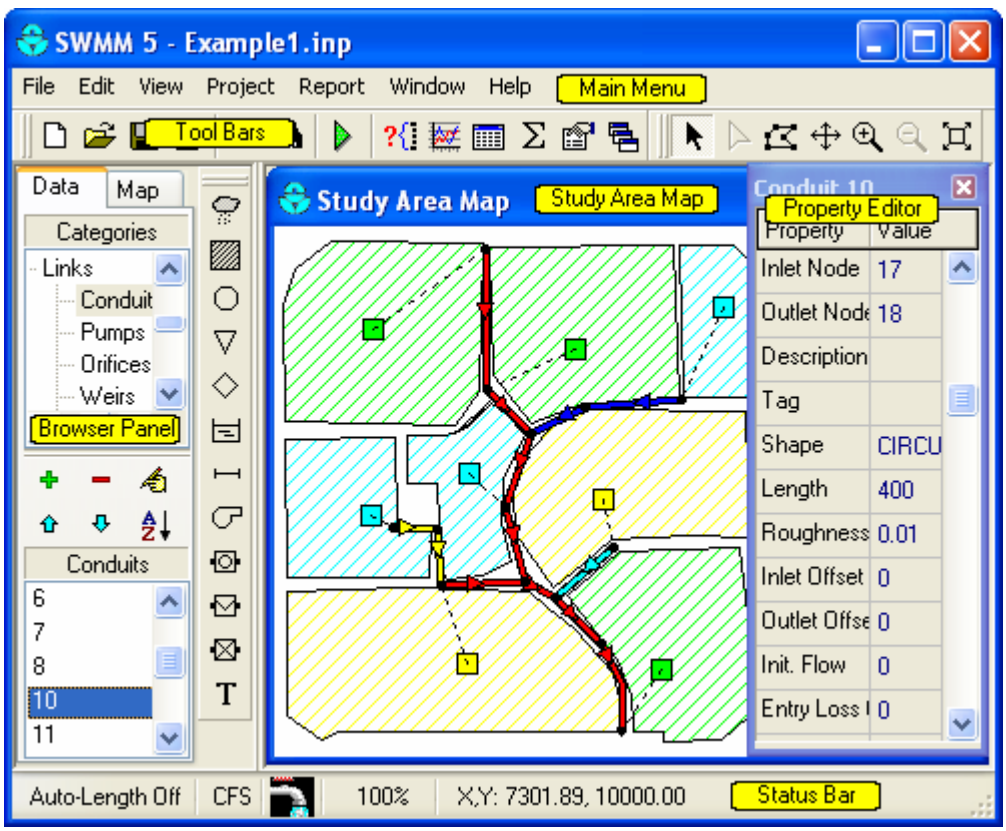
CHAPTER 4 - SWMM'S MAIN WINDOW

This chapter discusses the essential features of SWMM's workspace. It describes the main menu bar, the tool and status bars, and the three windows used most often – the Study Area Map, the Browser, and the Property Editor. It also shows how to set program preferences.

4.1 Overview

The EPA SWMM main window is pictured below. It consists of the following user interface elements: a Main Menu, several Toolbars, a Status Bar, the Study Area Map window, a Browser panel, and a Property Editor window. A description of each of these elements is provided in the sections that follow.



4.2 Main Menu

The Main Menu located across the top of the EPA SWMM main window contains a collection of menus used to control the program. These include:

- File Menu
- Edit Menu
- View Menu
- Project Menu
- Report Menu
- Window Menu
- Help Menu

File Menu

The File Menu contains commands for opening and saving data files and for printing:

Command	*Description*
New	Creates a new SWMM project
Open	Opens an existing project
Reopen	Reopens a recently used project
Save	Saves the current project
Save As	Saves the current project under a different name
Export	Exports study area map to a file in a variety of formats
Combine	Combines two Routing Interface files together
Page Setup	Sets page margins and orientation for printing
Print Preview	Previews a printout of the currently active view (map, report, graph, or table)
Print	Prints the current view
Preferences	Sets program preferences
Exit	Exits EPA SWMM

Edit Menu

The Edit Menu contains commands for editing and copying:

Command	*Description*
Copy To	Copies the currently active view (map, report, graph or table) to the clipboard or to a file
Select Object	Enables the user to select an object on the map
Select Vertex	Enables the user to select the vertex of a subcatchment or link
Select Region	Enables the user to delineate a region on the map for selecting multiple objects
Select All	Selects all objects when the map is the active window or all cells of a table when a tabular report is the active window
Find	Locates a specific object on the map
Group Edit	Edits a property for the group of objects that fall within the outlined region of the map
Group Delete	Deletes a group of objects that fall within the outlined region of the map

View Menu

The View Menu contains commands for viewing the Study Area Map:

Command	*Description*
Dimensions	Sets reference coordinates and map units for the study area map
Backdrop	Allows a backdrop image to be added, positioned, and viewed
Pan	Pans across the map
Zoom In	Zooms in on the map
Zoom Out	Zooms out on the map
Full Extent	Redraws the map at full extent
Query	Highlights objects on the map that meet specific criteria
Overview	Toggles the display of the Overview Map
Objects	Toggles display of classes of objects on the map
Legends	Controls display of the map legends
Toolbars	Toggles display of tool bars
Options	Sets map appearance options

Project Menu

The Project menu contains commands related to the current project being analyzed:

Command	*Description*
Summary	Lists the number of each type of object in the project
Details	Shows a detailed listing of all project data
Defaults	Edits a project's default properties
Calibration Data	Registers files containing calibration data with the project
Run Simulation	Runs a simulation

Report Menu

The Report menu contains commands used to report analysis results in different formats:

Command	*Description*
Status	Displays a status report for the most recent simulation run
Graph	Displays simulation results in graphical form
Table	Displays simulation results in tabular form
Statistics	Displays a statistical analysis of simulation results
Options	Controls the display style of the currently active graph

Window Menu

The Window Menu contains commands for arranging and selecting windows within the SWMM workspace:

Command	*Description*
Cascade	Arranges windows in cascaded style, with the study area map filling the entire display area
Tile	Minimizes the study area map and tiles the remaining windows vertically in the display area
Close All	Closes all open windows except for the study area map
Window List	Lists all open windows; the currently selected window has the focus and is denoted with a check mark

Help Menu

The Help Menu contains commands for getting help in using EPA SWMM:

Command	*Description*
Help Topics	Displays the Help system's Table of Contents
How Do I	Displays a list of topics covering the most common operations
Measurement Units	Shows measurement units for all of SWMM's parameters
Error Messages	Lists the meaning of all error messages
Tutorial	Presents a short tutorial introducing the user to EPA SWMM
About	Lists information about the version of EPA SWMM being used

4.3 Toolbars

Toolbars provide shortcuts to commonly used operations. There are four such toolbars:

- Standard Toolbar
- Map Toolbar
- Object Toolbar
- Animator Toolbar

Except for the Animator Toolbar, all toolbars can be docked underneath the Main Menu bar, docked on the right side of the Browser Panel or dragged to any location on the EPA SWMM workspace. When undocked, they can also be re-sized.

Toolbars can be made visible or invisible by selecting **View >> Toolbars** from the Main Menu.

Standard Toolbar

The Standard Toolbar contains buttons for the following commonly used commands:

Creates a new project (**File >> New**)

Opens an existing project (**File >> Open**)

Saves the current project (**File >> Save**)

Prints the currently active window (**File >> Print**)

Copies selection to the clipboard or to a file (**Edit >> Copy To**)

Finds a specific item on the map (**Edit >> Find**)

Runs a simulation (**Project >> Run Simulation**)

Makes a visual query of the study area map (**View >> Query**)

Creates a new graph of simulation results (**Report >> Graph**)

Creates a new table of simulation results (**Report >> Table**)

Performs a statistical analysis of simulation results (**Report >> Statistics**)

Modifies display options for the currently active view (**View >> Options** or **Report >> Options**)

Arranges windows in cascaded style, with the study area map filling the entire display area (**Window >> Cascade**)

Map Toolbar

The Map Toolbar contains the following buttons for viewing the study area map:

Selects an object on the map (**Edit >> Select Object**)

Selects link or subcatchment vertex points (**Edit >> Select Vertex**)

Selects a region on the map (**Edit >> Select Region**)

Pans across the map (**View >> Pan**)

Zooms in on the map (**View >> Zoom In**)

Zooms out on the map (**View >> Zoom Out**)

Draws map at full extent (**View >> Full Extent**)

Object Toolbar

The Object Toolbar contains buttons for adding objects to the study area map:

Adds a rain gage to the map

Adds a subcatchment to the map

Adds a junction node to the map

Adds an outfall node to the map

Adds a flow divider node to the map

Adds a storage unit node to the map

Adds a conduit link to the map

Adds a pump link to the map

Adds an orifice link to the map

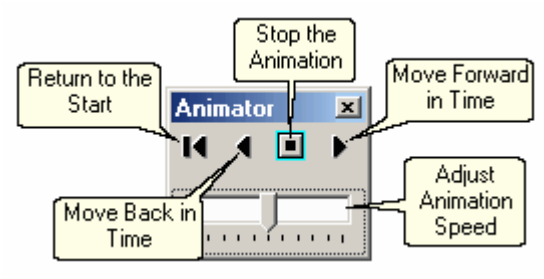
Adds a weir link to the map

Adds an outlet link to the map

Adds a label to the map

Animator Toolbar

The Animator Toolbar contains controls for animating the Study Area Map and all Profile Plots through time (i.e., updating map color-coding and hydraulic grade line profile depths as the simulation time clock is automatically moved forward or back). The toolbar and the meaning of its controls are shown below.



The Animator toolbar is initially hidden on program startup. To make the toolbar visible, select **View >> Toolbars >> Animator** from the Main Menu.

4.4 Status Bar

The Status Bar appears at the bottom of SWMM's Main Window and is divided into five sections:

Auto-Length
Indicates whether the automatic computation of conduit lengths and subcatchment areas is turned on or off. Right-click over this section to toggle this feature on/off.

Flow Units
Displays the current flow units that are in effect.

Run Status
A faucet icon shows:

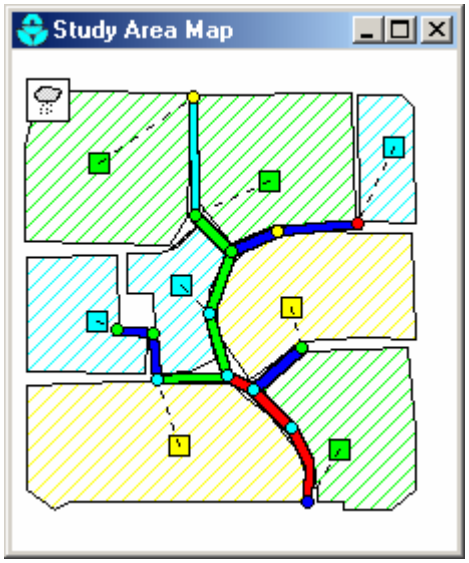
- no running water if simulation results are not available,
- running water when simulation results are available,
- a broken faucet when simulation results are available but may be invalid because project data have been modified.

Zoom Level
Displays the current zoom level for the map (100% is full-scale).

XY Location
Displays the map coordinates of the current position of the mouse pointer

4.5 Study Area Map

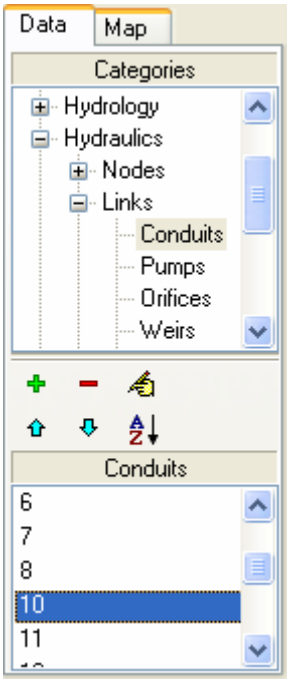
The Study Area Map (shown below) provides a planar schematic diagram of the objects comprising a drainage system. Its pertinent features are as follows:



- The location of objects and the distances between them do not necessarily have to conform to their actual physical scale.
- Selected properties of these objects, such as water quality at nodes or flow velocity in links, can be displayed by using different colors. The color-coding is described in a Legend, which can be edited.
- New objects can be directly added to the map and existing objects can be selected for editing, deleting, and repositioning.
- A backdrop drawing (such as a street or topographic map) can be placed behind the network map for reference.
- The map can be zoomed to any scale and panned from one position to another.
- Nodes and links can be drawn at different sizes, flow direction arrows added, and object symbols, ID labels and numerical property values displayed.
- The map can be printed, copied onto the Windows clipboard, or exported as a DXF file or Windows metafile.

4.6 Data Browser

The Data Browser panel (shown below) appears when the Data tab on the left panel of the SWMM's workspace is selected. It provides access to all of the data objects in a project. The vertical sizes of the list boxes in the browser can be adjusted by using the splitter bar located just below the Categories box. The width of the Data Browser panel can be adjusted by using the splitter bar located along its right edge.



The Categories list box displays the various categories of data objects available to a SWMM project. The lower list box lists the name of each individual object of the currently selected data category.

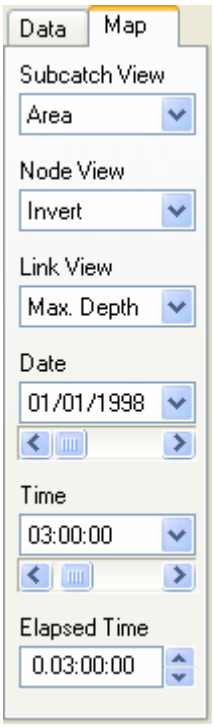
The buttons between the two list boxes of the Data Browser are used as follows:

- adds a new object
- deletes the selected object
- edits the selected object
- moves the selected object up one position
- moves the selected object down one position
- sorts the objects in ascending order

Selections made in the Data Browser are coordinated with objects highlighted on the Study Area Map, and vice versa. For example, selecting a conduit in the Data Browser will cause that conduit to be highlighted on the map, while selecting it on the map will cause it to become the selected object in the Data Browser.

4.7 Map Browser

The Map Browser panel (shown below) appears when the Map tab on the left panel of the SWMM's workspace is selected. It controls the mapping themes and time periods to be viewed on the Study Area Map. The width of the Map Browser panel can be adjusted by using the splitter bar located along its right edge.



The selections available on the Map Browser are as follows:

Subcatch View - selects the theme to display for the subcatchment areas shown on the Study Area Map.

Node View - selects the theme to display for the drainage system nodes shown on the Study Area Map.

Link View - selects the theme to display for the drainage system links shown on the Study Area Map.

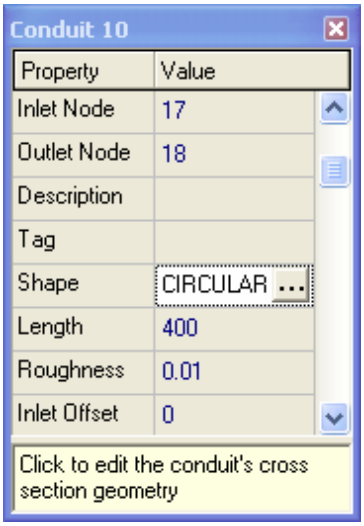
Date - selects the day for which simulation results will be viewed.

Time - selects the hour of the current day for which simulation results will be viewed.

Elapsed Time - selects the elapsed time from the start of the simulation for which results will be viewed.

4.8 Property Editor

The Property Editor (shown to the right) is used to edit the properties of data objects that can appear on the Study Area Map. It is invoked when one of these objects is selected (either on the Study Area Map or in the Data Browser) and double-clicked or when the Data Browser's Edit button is clicked.

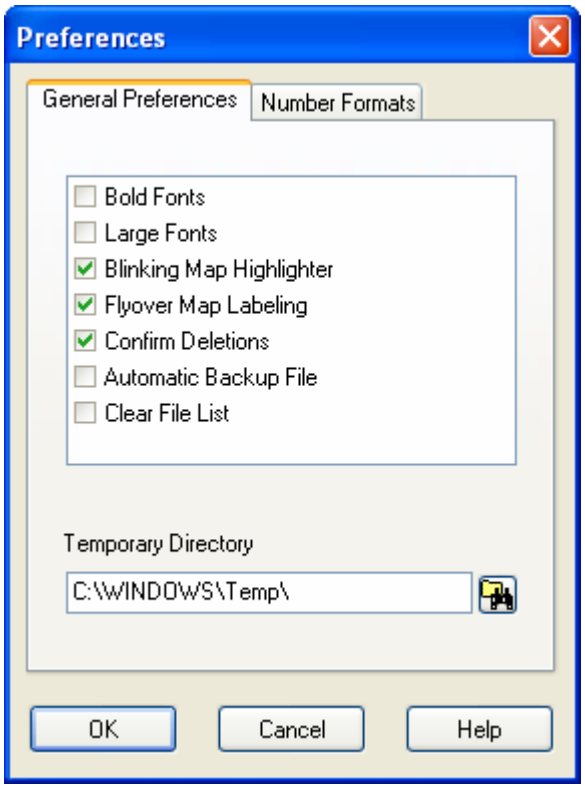


Key features of the Proeprty Editor include:

- The Editor is a grid with two columns - one for the property's name and the other for its value.
- The columns can be re-sized by re-sizing the header at the top of the Editor with the mouse.
- A hint area is displayed at the bottom of the Editor with an expanded description of the property being edited. The size of this area can be adjusted by dragging the splitter bar located just above it.
- The Editor window can be moved and re-sized via the normal Windows operations.
- Depending on the property, the value field can be one of the following:
  - a text box in which you enter a value
  - a dropdown combo box from which you select a value from a list of choices
  - a dropdown combo box in which you can enter a value or select from a list of choices
  - an ellipsis button which you click to bring up a specialized editor.
- The property field in the Editor that currently has the focus will be highlighted with a white background.
- Both the mouse and the Up and Down arrow keys on the keyboard can be used to move between property fields.
- To begin editing the property with the focus, either begin typing a value or hit the Enter key.
- To have the program accept edits made in a property field, either press the Enter key or move to another property. To cancel the edits, press the Esc key.
- The Property Editor can be hidden by clicking the button in the upper right corner of its title bar.

4.9 Setting Program Preferences

Program preferences allow one to customize certain program features. To set program preferences, select **Preferences** from the **File** menu. A Preferences dialog form will appear containing two tabbed pages – one for General Preferences and one for Number Formats.



General Preferences

The following preferences can be set on the General Preferences page of the Preferences dialog:

Preference	*Description*
Bold Fonts	Check to use bold fonts in all windows
Large Fonts	Check to use large size fonts in all windows
Blinking Map Highlighter	Check to make the selected object on the study area map blink on and off
Flyover Map Labeling	Check to display the ID label and current theme value in a hint-style box whenever the mouse is placed over an object on the study area map
Confirm Deletions	Check to display a confirmation dialog box before deleting any object
Automatic Backup File	Check to save a backup copy of a newly opened project to disk named with a .bak extension
Clear File List	Check to clear the list of most recently used files that appears when **File >> Reopen** is selected from the Main Menu
Temporary Directory	Name of the directory (folder) where EPA SWMM writes its temporary files

The Temporary Directory must be a file directory (folder) where the user has write privileges and must have sufficient space to temporarily store files which can easily grow to several tens of megabytes for larger study areas and simulation runs. The original default is the folder where Windows writes its temporary files.

Number Format Preferences

The Number Formats page of the Preferences dialog controls the number of decimal places displayed when simulation results are reported. Use the dropdown list boxes to select a specific Subcatchment, Node or Link parameter, and then use the edit boxes next to them to select the number of decimal places to use when displaying computed results for the parameter. Note that the number of decimal places displayed for any particular input design parameter, such as slope, diameter, length, etc. is whatever the user enters.

CHAPTER 5 - WORKING WITH PROJECTS

Project files contain all of the information used to model a study area. They are usually named with a .INP extension. This section describes how to create, open, and save EPA SWMM projects as well as setting their default properties.

5.1 Creating a New Project

To create a new project:

1. Select **File >> New** from the Main Menu or click on the Standard Toolbar.
2. You will be prompted to save the existing project (if changes were made to it) before the new project is created.
3. A new, unnamed project is created with all options set to their default values.

A new project is automatically created whenever EPA SWMM first begins.

If you are going to use a backdrop image with automatic area and length calculation, then it is recommended that you set the map dimensions immediately after creating the new project (see *Setting the Map's Dimensions*).

5.2 Opening an Existing Project

To open an existing project stored on disk:

1. Either select **File >> Open** from the Main Menu or click on the Standard Toolbar.
2. You will be prompted to save the current project (if changes were made to it).
3. Select the file to open from the Open File dialog form that will appear.
4. Click **Open** to open the selected file.

To open a project that was worked on recently:

1. Select **File >> Reopen** from the Main Menu.
2. Select a file from the list of recently used files to open.

5.3 Saving a Project

To save a project under its current name either select **File >> Save** from the Main Menu or click on the Standard Toolbar.

To save a project using a different name:

1. Select **File >> Save As** from the Main Menu.
2. A standard File Save dialog form will appear from which you can select the folder and name that the project should be saved under.

5.4 Setting Project Defaults

Each project has a set of default values that are used unless overridden by the SWMM user. These values fall into three categories:

- Default ID labels (labels used to identify nodes and links when they are first created)
- Default subcatchment properties (e.g., area, width, slope, etc.)
- Default node/link properties (e.g., node invert, conduit length, routing method).

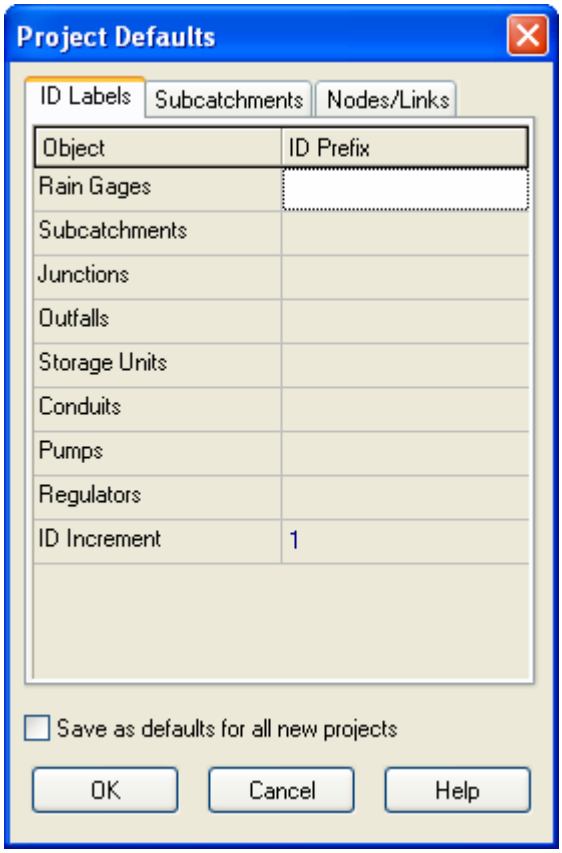
To set default values for a project:

1. Select **Project >> Defaults** from the Main Menu.
2. A Project Defaults dialog will appear with three pages, one for each category listed above.
3. Check the box in the lower left of the dialog form if you want to save your choices for use in all new future projects as well.
4. Click **OK** to accept your choice of defaults.

The specific items for each category of defaults will be discussed next.

Default ID Labels

The ID Labels page of the Project Defaults dialog form is used to determine how SWMM will assign default ID labels for the visual project components when they are first created. For each type of object you can enter a label prefix in the corresponding entry field or leave the field blank if an object's default name will simply be a number. In the last field you can enter an increment to be used when adding a numerical suffix to the default label. As an example, if C were used as a prefix for Conduits along with an increment of 5, then as conduits are created they receive default names of C5, C10, C15 and so on. An object's default name can be changed by using the Property Editor for visual objects or the object-specific editor for non-visual objects.



Default Subcatchment Properties

The Subcatchment page of the Project Defaults dialog sets default property values for newly created subcatchments. These properties include:

- Subcatchment Area
- Characteristic Width
- Slope
- % Impervious
- Impervious Area Manning's N
- Pervious Area Manning's N
- Impervious Area Depression Storage
- Pervious Area Depression Storage
- % of Impervious Area with No Depression Storage
- Infiltration Method

The default properties of a subcatchment can be modified later by using the Property Editor.

Default Node/Link Properties

The Nodes/Links page of the Project Defaults dialog sets default property values for newly created nodes and links. These properties include:

- Node Invert Elevation
- Node Maximum Depth

- Conduit Length
- Conduit Shape and Size
- Conduit Roughness
- Flow Units
- Routing Method

These default properties can be modified later by using the Property Editor.

The choice of flow units determines whether US or metric units are used for all other quantities. Default values are not automatically adjusted when the unit system is changed from US to metric (or vice versa).

5.5 Calibration Data

SWMM can compare the results of a simulation with measured field data in its Time Series Plots, which are discussed in section 9.4. Before SWMM can use such calibration data they must be entered into a specially formatted text file and registered with the project.

Calibration Files

Calibration Files contain measurements of a single parameter at one or more locations that can be compared with simulated values in Time Series Plots. Separate files can be used for each of the following parameters:

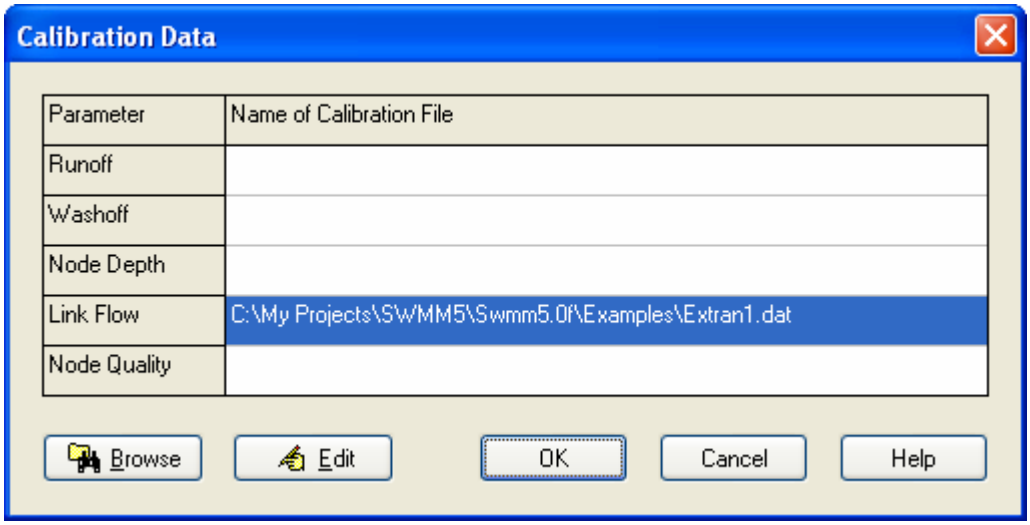
- Subcatchment Runoff
- Subcatchment Pollutant Washoff
- Node Depth
- Node Inflow
- Node Water Quality
- Link Flow

The format of the file is described in Section 11.5.

Registering Calibration Data

To register calibration data residing in a Calibration File:

1. Select **Project >> Calibration Data** from the Main Menu.
2. In the Calibration Data dialog form shown below, click in the box next to the parameter (e.g., node depth, link flow, etc.) whose calibration data will be registered.
3. Either type in the name of a Calibration File for this parameter or click the **Browse** button to search for it.
4. Click the **Edit** button if you want to open the Calibration File in Windows NotePad for editing.
5. Repeat steps 2 - 4 for any other parameters that have calibration data.
6. Click **OK** to accept your selections.



5.6 Viewing All Project Data

A listing of all project data (with the exception of map coordinates) can be viewed in a non-editable window, formatted for input to SWMM's computational engine. This can be useful for checking data consistency and to make sure that no key components are missing. To view such a listing, select **Project >> Details** from the Main Menu. The format of the data in this listing is the same as that used when the file is saved to disk. It is described in detail in Appendix D.2.

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CHAPTER 6 - WORKING WITH OBJECTS

SWMM uses various types of objects to model a drainage area and its conveyance system. This section describes how these objects can be created, selected, edited, deleted, and repositioned.

6.1 Types of Objects

SWMM contains both physical objects that can appear on its Study Area Map, and non-physical objects that encompass design, loading, and operational information. These objects, which are listed in the Data Browser and were described in Chapter 3, consist of the following:

Project Title/Notes	Links
Simulation Options	Transects
Climatology	Controls
Rain Gages	Pollutants
Subcatchments	Land Uses
Aquifers	Curves
Snow Packs	Time Series
RDII Hydrographs	Time Patterns
Nodes	Map Labels

6.2 Adding Objects

Visual objects are those that can appear on the Study Area Map and include Rain Gages, Subcatchments, Nodes, Links, and Map Labels. With the exception of Map Labels, there are two ways to add these objects into a project:

- selecting the object's icon from the Object Toolbar and then clicking on the map,
- selecting the object's category in the Data Browser and clicking the Browser's button.

The first method makes the object appear on the map and is therefore recommended. With the second method, the object will not appear on the map until X,Y coordinates are entered manually by editing the object's properties. What follows are more specific instructions for adding each type of object to a project.

Adding a Rain Gage

To add a Rain Gage using the Object Toolbar:

1. Click on the toolbar.
2. Move the mouse to the desired location on the map and click.

To add a Rain Gage using the Data Browser:

1. Select Rain Gages from the list of categories.
2. Click the button.
3. Enter the rain gage's X and Y coordinates in the Property Editor if you want it to appear on the study area map.

Adding a Subcatchment

To add a Subcatchment using the Object Toolbar:

1. Click on the toolbar.
2. Use the mouse to draw a polygon outline of the subcatchment on the map:
   - left-click at each vertex
   - right-click to close the polygon
   - press the <**Esc**> key if you wish to cancel the action.

To add a Subcatchment using the Data Browser:

1. Select Subcatchments from the list of object categories.
2. Click the button.
3. Enter the X and Y coordinates of the subcatchment's centroid in the Property Editor if you want it to appear on the study area map.

Adding a Node

To add a Node using the Object Toolbar:

1. Click the button for the type of node to add (if its not already depressed):

   for a junction

   for an outfall

   for a flow divider

   for a storage unit.
2. Move the mouse to the desired location on the map and click.

To add a Node using the Data Browser:

1. Select the type of node (Junction, Outfall, Flow Divider, or Storage Unit from the categories list of the Data Browser.
2. Click the button.
3. Enter the node's X and Y coordinates in the Property Editor if you want it to appear on the study area map.

Adding a Link

To add a Link using the Object Toolbar:

1. Click the button corresponding to the type of link to add (if its not already depressed):

   for a Conduit

   for a Pump

   for an Orifice

   for a Weir

   for an Outlet.

2. On the study area map, click the mouse on the link's inlet (upstream) node.
3. Move the mouse in the direction of the link's outlet (downstream) node, clicking at all intermediate points needed to define the link alignment.
4. Click the mouse a final time over the link's outlet (downstream) node.

Pressing the right mouse button or the <**Esc**> key while drawing a link will cancel the operation.

To add a Link using the Data Browser:

1. Select the type of link to add from the categories listed in the Data Browser.
2. Click the button.
3. Enter the names of the inlet and outlet nodes of the link in the Property Editor.

Adding a Map Label

To add a text label to the Study Area Map:

1. Click the Text button T on the Object Toolbar.
2. Click the mouse on the map where the top left corner of the label should appear.
3. Enter the text for the label.
4. Press the **Enter** key to accept the label or <**Esc**> to cancel.

Adding a Non-visual Object

To add an object belonging to a class that is not displayable on the Study Area Map (which includes Climatology, Aquifers, Snow Packs, Unit Hydrographs, Transects, Control Rules, Pollutants, Land Uses, Curves, Time Series, and Time Patterns):

1. Select the object's category from the list in the Data Browser
2. Click the button.

3. Edit the object's properties in the special editor dialog form that appears (see Appendix C for descriptions of these editors).

6.3 Selecting and Moving Objects

To select an object on the map:

1. Make sure that the map is in Selection mode (the mouse cursor has the shape of an arrow pointing up to the left). To switch to this mode, either click the Select Object button on the Map Toolbar or choose **Edit >> Select Object** from the Main Menu.
2. Click the mouse over the desired object on the map.

To select an object using the Data Browser:

1. Select the object's category from the upper list in the Browser.
2. Select the object from the lower list in the Browser.

Rain gages, subcatchments, and nodes can be moved to another location on the Study Area Map. To move an object to another location:

1. Select the object on the map.
2. With the left mouse button held down over the object, drag it to its new location.
3. Release the mouse button.

The following alternative method can also be used:

1. Select the object to be moved from the Data Browser (it must be either a rain gage, subcatchment, node, or map label).
2. With the left mouse button held down, drag the item from the Items list box of the Data Browser to its new location on the map.
3. Release the mouse button.

Note that the second method can be used to place objects on the map that were imported from a project file that had no coordinate information included in it.

6.4 Editing Objects

To edit an object appearing on the Study Area Map:

1. Select the object on the map.
2. If the Property Editor is not visible either:
   - double click on the object
   - or right-click on the object and select Properties from the pop-up menu that appears
   - or click on in the Data Browser.

3. Edit the object's properties in the Property Editor.

Appendix B lists the properties associated with each of SWMM's visual objects.

To edit an object listed in the Data Browser:

1. Select the object in the Data Browser.
2. Either:
   - click on in the Data Browser,
   - or double-click the item in the Objects list,
   - or press the **Enter** key.

Depending on the class of object selected, a special property editor will appear in which the object's properties can be modified. Appendix C describes all of the special property editors used with SWMM's non-visual objects.

The unit system in which object properties are expressed depends on the choice of units for flow rate. Using a flow rate expressed in cubic feet, gallons or acre-feet implies that US units will be used for all quantities. Using a flow rate expressed in liters or cubic meters means that SI metric units will be used. Flow units are selected either from the project's default Node/Link properties (see Section 5.4) or from its General Simulation Options (see Section 8.1). The units used for all properties are listed in Appendix A.1.

6.5 Converting an Object

It is possible to convert a node or link from one type to another without having to first delete the object and add a new one in its place. An example would be converting a Junction node into an Outfall node, or converting an Orifice link into a Weir link. To convert a node or link to another type:

1. Right-click the object on the map.
2. Select **Convert To** from the popup menu that appears.
3. Select the new type of node or link to convert to from the sub-menu that appears.
4. Edit the object to provide any data that was not included with the previous type of object.

Only data that is common to both types of objects will be preserved after an object is converted to a different type. For nodes this includes its name, position, description, tag, external inflows, treatment functions, and invert elevation. For links it includes just its name, end nodes, description, and tag.

6.6 Copying and Pasting Objects

The properties of an object displayed on the Study Area Map can be copied and pasted into another object from the same category.

To copy the properties of an object to SWMM's internal clipboard:

1. Right-click the object on the map.
2. Select **Copy** from the pop-up menu that appears.

To paste copied properties into an object:

1. Right-click the object on the map.
2. Select **Paste** from the pop-up menu that appears.

Only data that can be shared between objects of the same type can be copied and pasted. Properties not copied include the object's name, coordinates, end nodes (for links), Tag property and any descriptive comment associated with the object. For Map Labels, only font properties are copied and pasted.

6.7 Shaping and Reversing Links

Links can be drawn as polylines containing any number of straight-line segments that define the alignment or curvature of the link. Once a link has been drawn on the map, interior points that define these line segments can be added, deleted, and moved. To edit the interior points of a link:

1. Select the link to edit on the map and put the map in Vertex Selection mode by either clicking on the Map Toolbar, selecting **Edit >> Select Vertex** from the Main Menu, or right clicking on the link and selecting **Vertices** from the popup menu.
2. The mouse pointer will change shape to an arrow tip, and any existing vertex points on the link will be displayed as small open squares. The currently selected vertex will be displayed as a filled square. To select a particular vertex, click the mouse over it.
3. To add a new vertex to the link, right-click the mouse and select **Add Vertex** from the popup menu (or simply press the Insert key on the keyboard).
4. To delete the currently selected vertex, right-click the mouse and select **Delete Vertex** from the popup menu (or simply press the Delete key on the keyboard).
5. To move a vertex to another location, drag it to its new position with the left mouse button held down.
6. While in Vertex Selection mode you can begin editing the vertices for another link by simply clicking on the link. To leave Vertex Selection mode, right-click on the map and select **Quit Editing** from the popup menu, or simply select one of the other buttons on the Map Toolbar.

A link can also have its direction reversed (i.e., its end nodes switched) by right clicking on it and selecting **Reverse** from the pop-up menu that appears. Normally, links should be oriented so that the upstream end is at a higher elevation than the downstream end.

6.8 Shaping a Subcatchment

Subcatchments are drawn on the Study Area Map as closed polygons. To edit or add vertices to the polygon, follow the same procedures used for links. If the subcatchment is originally drawn or is edited to have two or less vertices, then only its centroid symbol will be displayed on the Study Area Map.

6.9 Deleting an Object

To delete an object:

1. Select the object on the map or from the Data Browser.
2. Either click the button on the Data Browser or press the <**Delete**> key on the keyboard.

You can require that all deletions be confirmed before they take effect. See the General Preferences page of the Program Preferences dialog box described in Section 4.9.

6.10 Editing or Deleting a Group of Objects

A group of objects located within an irregular region of the Study Area Map can have a common property edited or be deleted all together. To select such a group of objects:

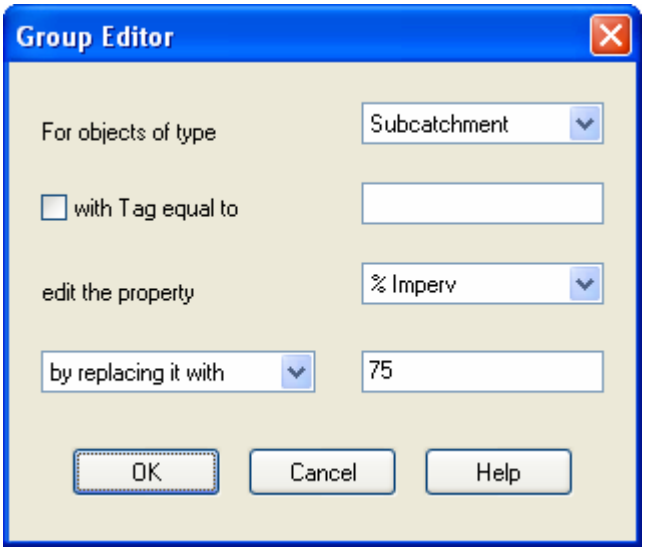
1. Choose **Edit >> Select Region** from the Main Menu or click on the Map Toolbar.
2. Draw a polygon around the region of interest on the map by clicking the left mouse button at each successive vertex of the polygon.
3. Close the polygon by clicking the right button or by pressing the <**Enter**> key; cancel the selection by pressing the <**Esc**> key.

To select all objects in the project, whether in view or not, select **Edit >> Select All** from the Main Menu.

Once a group of objects has been selected, you can edit a common property shared among them:

1. Select **Edit >> Group Edit** from the Main Menu.
2. Use the Group Editor dialog that appears to select a property and specify its new value.

The Group Editor dialog, shown below, is used to modify a property for a selected group of objects. To use the dialog:



1. Select a class of object (Subcatchments, Infiltration, Junctions, or Conduits) to edit.
2. Check the "with Tag equal to" box if you want to add a filter that will limit the objects selected for editing to those with a specific Tag value. (For Infiltration, the Tag will be that of the subcatchment to which the infiltration parameters belong.)
3. Enter a Tag value to filter on if you have selected that option.
4. Select the property to edit.
5. Select whether to replace, multiply, or add to the existing value of the property. Note that for some non-numerical properties the only available choice is to replace the value.
6. In the lower-right edit box, enter the value that should replace, multiply, or be added to the existing value for all selected objects. Some properties will have an ellipsis button displayed in the edit box which should be clicked to bring up a specialized editor for the property.
7. Click **OK** to execute the group edit.

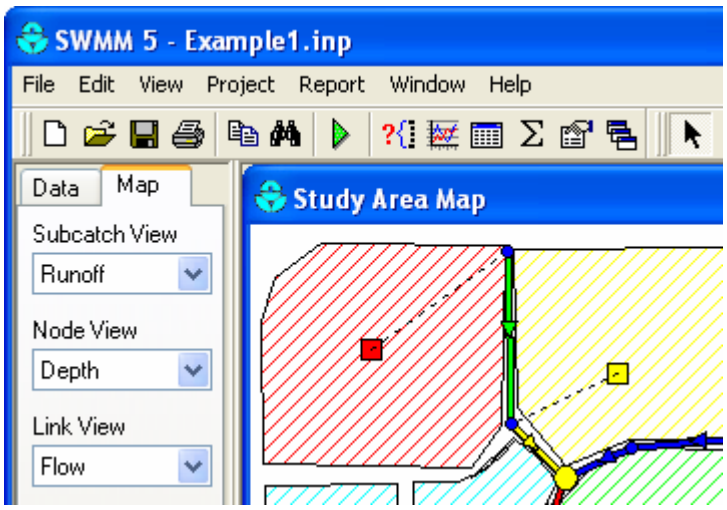
To delete the objects located within a selected area of the map, select **Edit >> Group Delete** from the Main Menu. Then select the categories of objects you wish to delete from the dialog box that appears. Recall that deleting a node will also delete any links connected to the node.

CHAPTER 7 - WORKING WITH THE MAP

EPA SWMM can display a map of the study area being modeled. This section describes how you can manipulate this map to enhance your visualization of the system.

7.1 Selecting a Map Theme

A map theme displays object properties in color-coded fashion on the Study Area Map. The dropdown list boxes on the Map Browser are used for selecting a theme to display for Subcatchments, Nodes and Links.

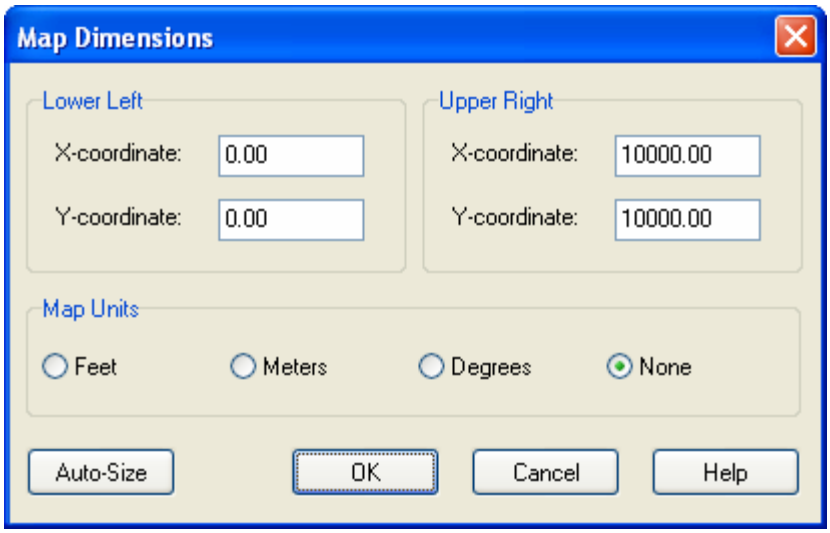


Methods for changing the color-coding associated with a theme are discussed in Section 7.9 below.

7.2 Setting the Map's Dimensions

The physical dimensions of the map can be defined so that map coordinates can be properly scaled to the computer's video display. To set the map's dimensions:

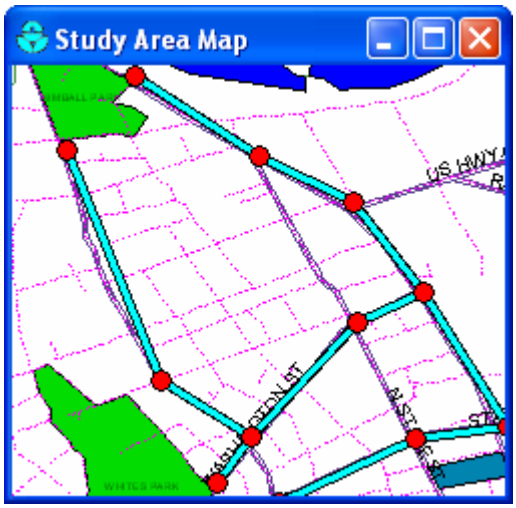
1. Select **View >> Dimensions** from the Main Menu.
2. Enter coordinates for the lower-left and upper-right corners of the map into the Map Dimensions dialog (see below) that appears or click the **Auto-Size** button to automatically set the dimensions based on the coordinates of the objects currently included in the map.
3. Select the distance units to use for these coordinates.
4. Click the **OK** button to resize the map.



If you are going to use a backdrop image with the automatic distance and area calculation feature, then it is recommended that you set the map dimensions immediately after creating a new project. Map distance units can be different from conduit length units. The latter (feet or meters) depend on whether flow rates are expressed in US or metric units. SWMM will automatically convert units if necessary.

7.3 Utilizing a Backdrop Image

SWMM can display a backdrop image behind the Study Area Map. The backdrop image might be a street map, utility map, topographic map, site development plan, or any other relevant picture or drawing. For example, using a street map would simplify the process of adding sewer lines to the project since one could essentially digitize the drainage system's nodes and links directly on top of it.

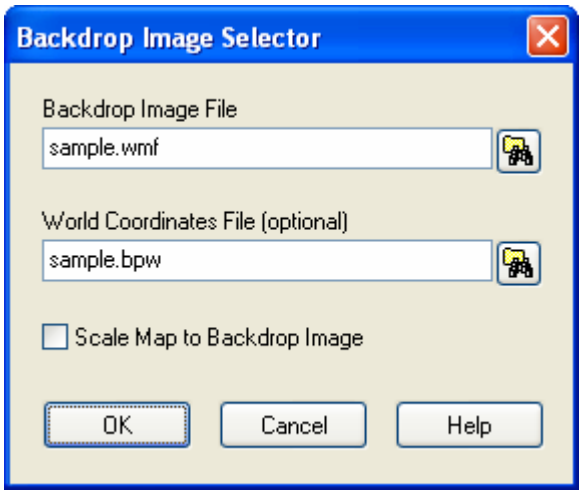


The backdrop image must be a Windows metafile, bitmap, or JPEG image created outside of SWMM. Once imported, its features cannot be edited, although its scale and viewing area will change as the map window is zoomed and panned. For this reason metafiles work better than bitmaps or JPEGs since they will not loose resolution when re-scaled. Most CAD and GIS programs have the ability to save their drawings and maps as metafiles.

Selecting **View >> Backdrop** from the Main Menu will display a sub-menu with the following commands:

- **Load** (loads a backdrop image file into the project)
- **Unload** (unloads the backdrop image from the project)
- **Align** (aligns the drainage system schematic with the backdrop)
- **Resize** (resizes the map dimensions of the backdrop)
- **Watermark** (toggles the backdrop image appearance between normal and lightened)

To load a backdrop image, select **View >> Backdrop >> Load** from the Main Menu. A Backdrop Image Selector dialog form will be displayed. The entries on this form are as follows:



Backdrop Image File

Enter the name of the file that contains the image. You can click the button to bring up a standard Windows file selection dialog from which you can search for the image file.

World Coordinates File

If a "world" file exists for the image, enter its name here, or click the button to search for it. A world file contains geo-referencing information for the image and can be created from the software that produced the image file or by using a text editor. It contains six lines with the following information:

Line 1: real world width of a pixel in the horizontal direction.
Line 2: X rotation parameter (not used).
Line 3: Y rotation parameter (not used).
Line 4: negative of the real world height of a pixel in the vertical direction.
Line 5: real world X coordinate of the upper left corner of the image.
Line 6: real world Y coordinate of the upper left corner of the image.

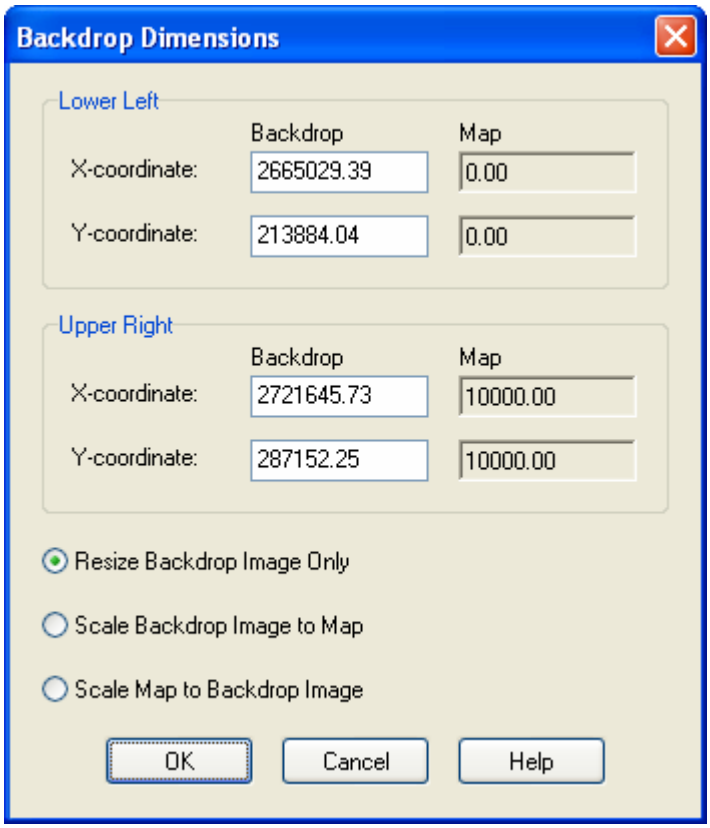
If no world file is specified, then the backdrop will be scaled to fit into the center of the map display window.

Scale Map to Backdrop Image

This option is only available when a world file has been specified. Selecting it forces the dimensions of the Study Area Map to coincide with those of the backdrop image. In addition, all existing objects on the map will have their coordinates adjusted so that they appear within the new map dimensions yet maintain their relative positions to one another. Selecting this option may then require that the backdrop be re-aligned so that its position relative to the drainage area objects is correct. How to do this is described below.

The backdrop image can be re-positioned relative to the drainage system by selecting **View >> Backdrop >> Align**. This allows the backdrop image to be moved across the drainage system (by moving the mouse with the left button held down) until one decides that it lines up properly.

The backdrop image can also be resized by selecting **View >> Backdrop >> Resize**. In this case the following Backdrop Dimensions dialog will appear.



The dialog lets you manually enter the X,Y coordinates of the backdrop's lower left and upper right corners. The Study Area Map's dimensions are also displayed for reference. While the dialog is visible you can view map coordinates by moving the mouse over the map window and noting the X,Y values displayed in SWMM's Status Panel (at the bottom of the main window).

Selecting the Resize Backdrop Image Only button will resize only the backdrop, and not the Study Area Map, according to the coordinates specified. Selecting the Scale Backdrop Image to Map button will position the backdrop image in the center of the Study Area

Map and have it resized to fill the display window without changing its aspect ratio. The map's lower left and upper right coordinates will be placed in the data entry fields for the backdrop coordinates, and these fields will become disabled. Selecting Scale Map to Backdrop Image makes the dimensions of the map coincide with the dimensions being set for the backdrop image. Note that this option will change the coordinates of all objects currently on the map so that their positions relative to one another remain unchanged. Selecting this option may then require that the backdrop be re-aligned so that its position relative to the drainage area objects is correct.

Exercise caution when selecting the Scale Map to Backdrop Image option in either the Backdrop Image Selector dialog or the Backdrop Dimensions dialog as it will modify the coordinates of all exisitng objects currently on the Study Area Map. You might want to save your project before carrying out this step in case the results are not what you expected.

The name of the backdrop image file and its map dimensions are saved along with the rest of a project's data whenever the project is saved to file.

For best results in using a backdrop image:

- Use a metafile, not a bitmap.
- If the image is loaded before any objects are added to the project then scale the map to it.

7.4 Zooming the Map

To Zoom In on the Study Area Map:

1. Select **View >> Zoom In** from the Main Menu or click on the Map Toolbar.
2. To zoom in 100% (i.e., 2X), move the mouse to the center of the zoom area and click the left button.
3. To perform a custom zoom, move the mouse to the upper left corner of the zoom area and with the left button pressed down, draw a rectangular outline around the zoom area. Then release the left button.

To Zoom Out on the Study Area Map:

1. Select **View >> Zoom Out** from the Main Menu or click on the Map Toolbar.
2. Move the mouse to the center of the new zoom area and click the left button.
3. The map will be returned to its previous zoom level.

7.5 Panning the Map

To pan across the Study Area Map window:

1. Select **View >> Pan** from the Main Menu or click on the Map Toolbar.

2. With the left button held down over any point on the map, drag the mouse in the direction you wish to pan in.
3. Release the mouse button to complete the pan.

To pan using the Overview Map (which is described in Section 7.10 below):

1. If not already visible, bring up the Overview Map by selecting **View >> Overview Map** from the Main Menu.
2. If the Study Area Map has been zoomed in, an outline of the current viewing area will appear on the Overview Map. Position the mouse within this outline on the Overview Map.
3. With the left button held down, drag the outline to a new position.
4. Release the mouse button and the Study Area Map will be panned to an area corresponding to the outline on the Overview Map.

7.6 Viewing at Full Extent

To view the Study Area Map at full extent, either:

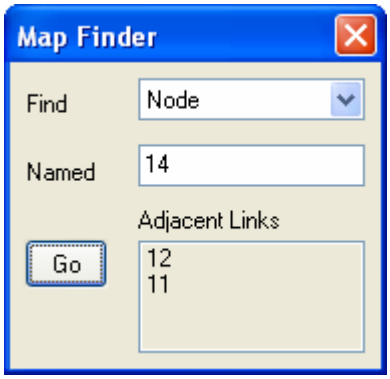
a) select **View >> Full Extent** from the Main Menu, or

b) press on the Map Toolbar.

7.7 Finding an Object

To find an object on the Study Area Map whose name is known:

1. Select **View >> Find** from the Main Menu or click on the Standard Toolbar.
2. In the Map Finder dialog that appears, select the type of object to find and enter its name.
3. Click the **Go** button.



If the object exists, it will be highlighted on the map and in the Data Browser. If the map is currently zoomed in and the object falls outside the current map boundaries, the map will be panned so that the object comes into view.

User-assigned object names in SWMM are not case sensitive. E.g., NODE123 is equivalent to Node123.

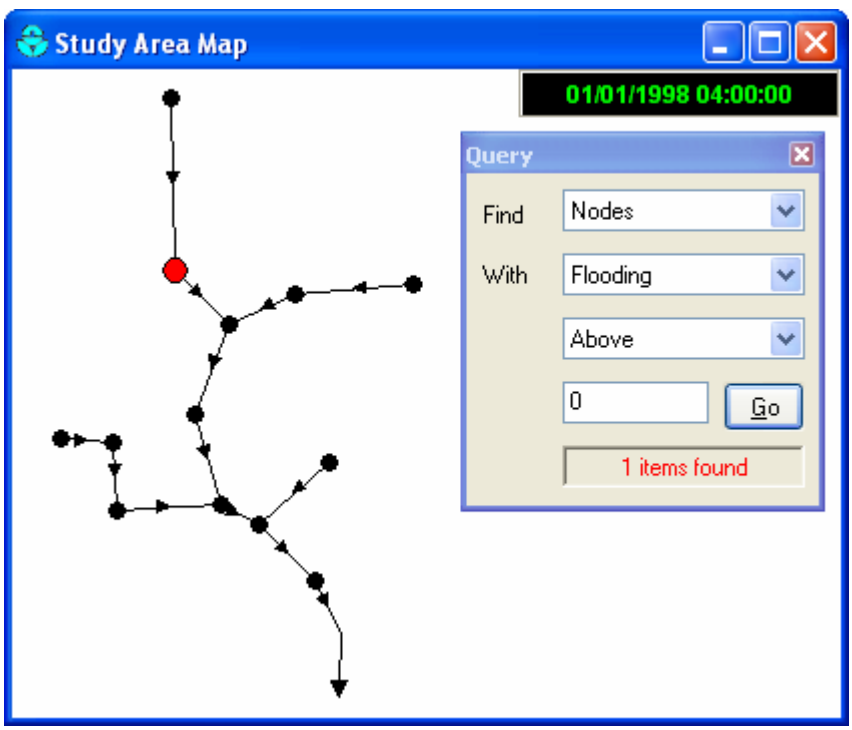
After an object is found, the Map Finder dialog will also list:

- the outlet connections for a subcatchment
- the connecting links for a node
- the connecting nodes for a link.

7.8 Submitting a Map Query

A Map Query identifies objects on the study area map that meet a specific criterion (e.g., nodes which flood, links with velocity below 2 ft/sec, etc.). To submit a map query:

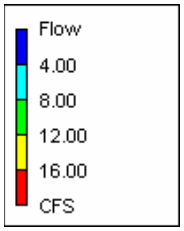
1. Select a time period in which to query the map from the Map Browser.
2. Select **View >> Query** or click on the Map Toolbar.
3. Fill in the following information in the Query dialog that appears:
   - Select whether to search for Subcatchments, Nodes or Links.
   - Select a parameter to query.
   - Select the appropriate operator: Above, Below, or Equals.
   - Enter a value to compare against.



4. Click the **Go** button. The number of objects that meet the criterion will be displayed in the Query dialog and each such object will be highlighted on the Study Area Map.
5. As a new time period is selected in the Browser, the query results are automatically updated.
6. You can submit another query using the dialog box or close it by clicking the button in the upper right corner.

After the Query box is closed the map will revert back to its original display.

7.9 Using the Map Legends



Map Legends associate a color with a range of values for the current theme being viewed. Separate legends exist for Subcatchments, Nodes, and Links. A Date/Time Legend is also available for displaying the date and clock time of the simulation period being viewed on the map.

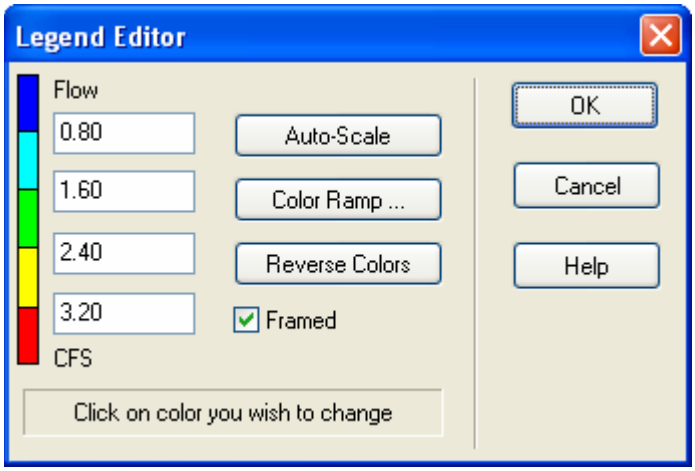
To display or hide a map legend:

1. Select **View >> Legends** from the Main Menu or right-click on the map and select Legends from the pop-up menu that appears
2. Click on the type of legend whose display should be toggled on or off.

A visible legend can also be hidden by double clicking on it.

To move a legend to another location press the left mouse button over the legend, drag the legend to its new location with the button held down, and then release the button.

To edit a legend, either select **View >> Legends >> Modify** from the Main Menu or right-click on the legend if it is visible. Then use the Legend Editor dialog that appears to modify the legend's colors and intervals.



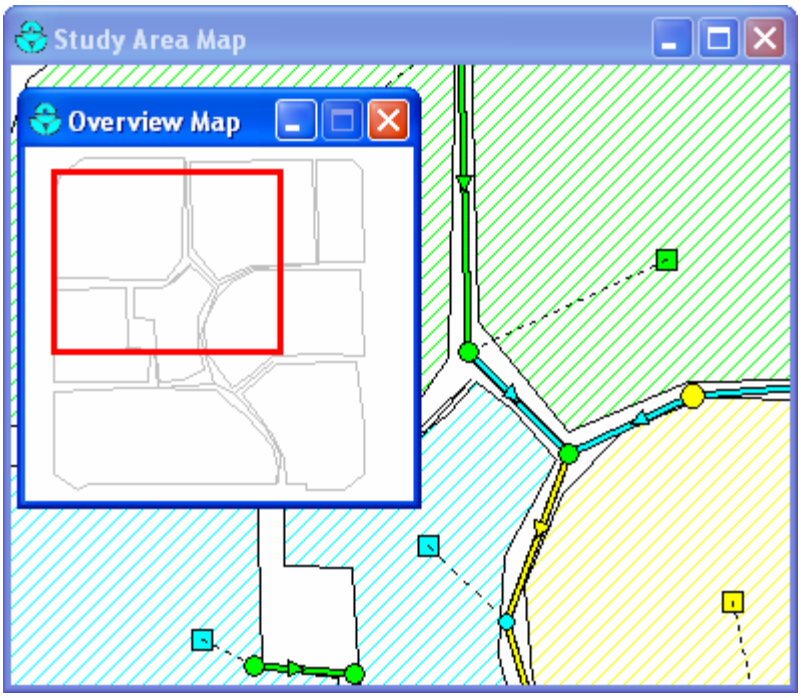
The Legend Editor is used to set numerical ranges to which different colors are assigned for viewing a particular parameter on the network map. It works as follows:

- Numerical values, in increasing order, are entered in the edit boxes to define the ranges. Not all four boxes need to have values.
- To change a color, click on its color band in the Editor and then select a new color from the Color Dialog that will appear.

- Click the **Auto-Scale** button to automatically assign ranges based on the minimum and maximum values attained by the parameter in question at the current time period.
- The **Color Ramp** button is used to select from a list of built-in color schemes.
- The **Reverse Colors** button reverses the ordering of the current set of colors (the color in the lowest range becomes that of the highest range and so on).
- Check **Framed** if you want a frame drawn around the legend.

7.10 Using the Overview Map

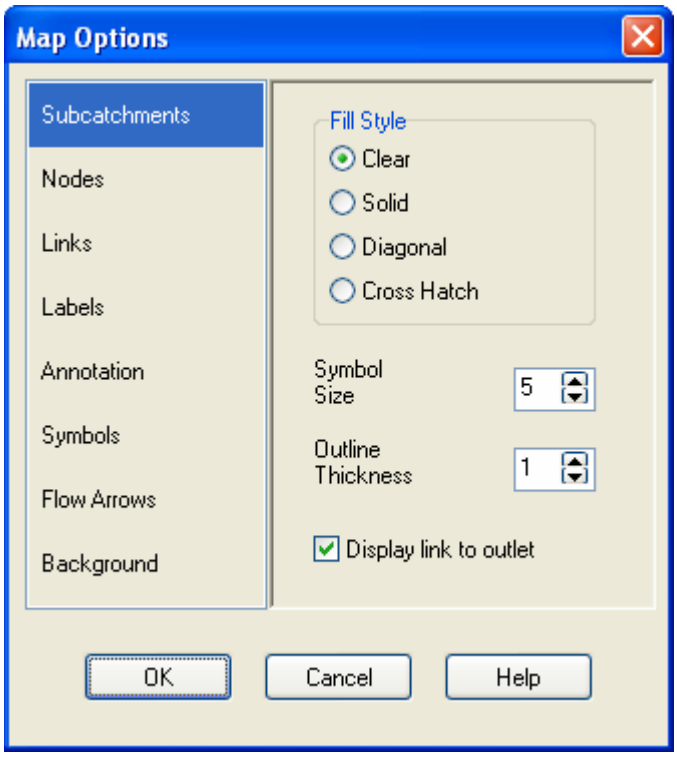
The Overview Map, as pictured below, allows one to see where in terms of the overall system the main Study Area Map is currently focused. This zoom area is depicted by the rectangular outline displayed on the Overview Map. As you drag this rectangle to another position the view within the main map will be redrawn accordingly. The Overview Map can be toggled on and off by selecting **View >> Overview Map** from the Main Menu. The Overview Map window can also be dragged to any position as well as be re-sized.



7.11 Setting Map Display Options

The Map Options dialog (shown below) is used to change the appearance of the Study Area Map. There are several ways to invoke it:

- select **View >> Options** from the Main Menu or,
- click the Options button on the Standard Toolbar when the Study Area Map window has the focus or,
- right-click on any empty portion of the map and select **Options** from the popup menu that appears.



The dialog contains a separate page, selected from the panel on the left side of the form, for each of the following display option categories:

- *Subcatchments* (controls fill style, symbol size, and outline thickness of subcatchment areas)
- *Nodes* (controls size of nodes and making size be proportional to value)
- *Links* (controls thickness of links and making thickness be proportional to value)
- *Labels* (turns display of map labels on/off)
- *Annotation* (displays or hides node/link ID labels and parameter values)
- *Symbols* (turns display of storage unit, pump, and regulator symbols on/off)
- *Flow Arrows* (selects visibility and style of flow direction arrows)
- *Background* (changes color of map's background)

Subcatchment Options

The Subcatchments page of the Map Options dialog controls how subcatchment areas are displayed on the study area map.

Option	*Description*
Fill Style	Selects style used to fill interior of subcatchment area
Symbol Size	Sets the size of the symbol (in pixels) placed at the centroid of a subcatchment area
Outline Thickness	Sets the thickness of the line used to draw a subcatchment's boundary; set to zero if no boundary should be displayed
Display Link to Outlet	If checked then a dashed line is drawn between the subcatchment centroid and the subcatchment's outlet node (or outlet subcatchment)

Node Options

The Nodes page of the Map Options dialog controls how nodes are displayed on the study area map.

Option	*Description*
Node Size	Selects node diameter in pixels
Proportional to Value	Select if node size should increase as the viewed parameter increases in value
Display Border	Select if a border should be drawn around each node (recommended for light-colored backgrounds)

Link Options

The Links page of the Map Options dialog controls how links are displayed on the map.

Option	*Description*
Link Size	Sets thickness of links displayed on map (in pixels)
Proportional to Value	Select if link thickness should increase as the viewed parameter increases in value
Display Border	Check if a black border should be drawn around each link

Label Options

The Labels page of the Map Options dialog controls how user-created map labels are displayed on the study area map.

Option	*Description*
Use Transparent Text	Check to display label with a transparent background (otherwise an opaque background is used)
At Zoom Of	Selects minimum zoom at which labels should be displayed; labels will be hidden at zooms smaller than this

Annotation Options

The Annotation page of the Map Options dialog form determines what kind of annotation is provided alongside of the objects on the study area map.

Option	*Description*
Rain Gage IDs	Check to display rain gage ID names
Subcatch IDs	Check to display subcatchment ID names
Node IDs	Check to display node ID names
Link IDs	Check to display link ID names
Subcatch Values	Check to display value of current subcatchment variable
Node Values	Check to display value of current node variable
Link Values	Check to display value of current link variable
Use Transparent Text	Check to display text with a transparent background (otherwise an opaque background is used)
Font Size	Adjusts the size of the font used to display annotation
At Zoom Of	Selects minimum zoom at which annotation should be displayed; all annotation will be hidden at zooms smaller than this

Symbol Options

The Symbols page of the Map Options dialog determines which types of objects are represented with special symbols on the map.

Option	*Description*
Display Node Symbols	If checked then special node symbols will be used
Display Link Symbols	If checked then special link symbols will be used
At Zoom Of	Selects minimum zoom at which symbols should be displayed; symbols will be hidden at zooms smaller than this

Flow Arrow Options

The Flow Arrows page of the Map Options dialog controls how flow-direction arrows are displayed on the map.

Option	*Description*
Arrow Style	Selects style (shape) of arrow to display (select None to hide arrows)
Arrow Size	Sets arrow size
At Zoom Of	Selects minimum zoom at which arrows should be displayed; arrows will be hidden at zooms smaller than this

Flow direction arrows will only be displayed after a successful simulation has been made and a computed parameter has been selected for viewing. Otherwise the direction arrow will point from the user-designated start node to end node.

Background Options

The Background page of the Map Options dialog offers a selection of colors used to paint the map's background with.

7.12 Exporting the Map

The full extent view of the study area map can be saved to file using either:

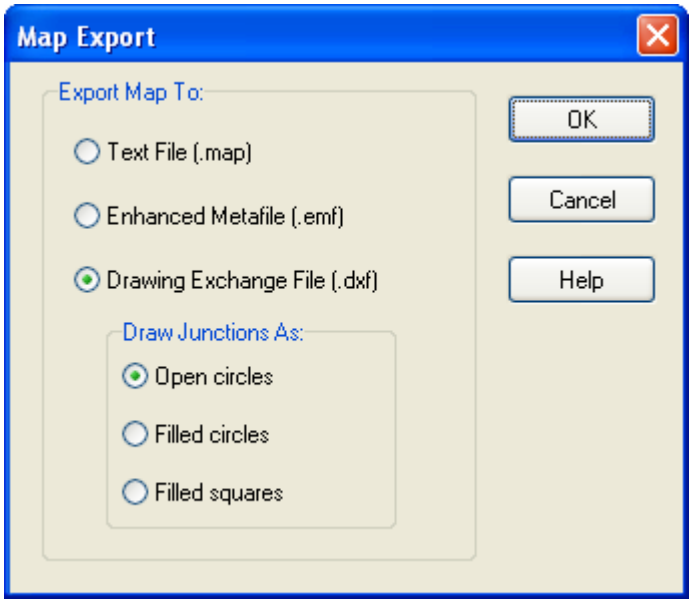
- Autodesk's DXF (Drawing Exchange Format) format,
- the Windows enhanced metafile (EMF) format,
- EPA SWMM's own ASCII text (.map) format.

The DXF format is readable by many Computer Aided Design (CAD) programs. Metafiles can be inserted into word processing documents and loaded into drawing programs for re-scaling and editing. Both formats are vector-based and will not lose resolution when they are displayed at different scales.

To export the map to a DXF, metafile, or text file:

1. Select **File >> Export >> Map**.
2. In the Map Export dialog that appears select the format that you want the map saved in.
3. If you select DXF format, you have a choice of how nodes will be represented in the DXF file. They can be drawn as filled circles, as open circles, or as filled squares. Not all DXF readers can recognize the format used in the DXF file to draw a filled circle. Also note that map annotation, such as node and link ID labels, will not be exported, but map label objects will be.

4. After choosing a format, click **OK** and enter a name for the file in the Save As dialog that appears.



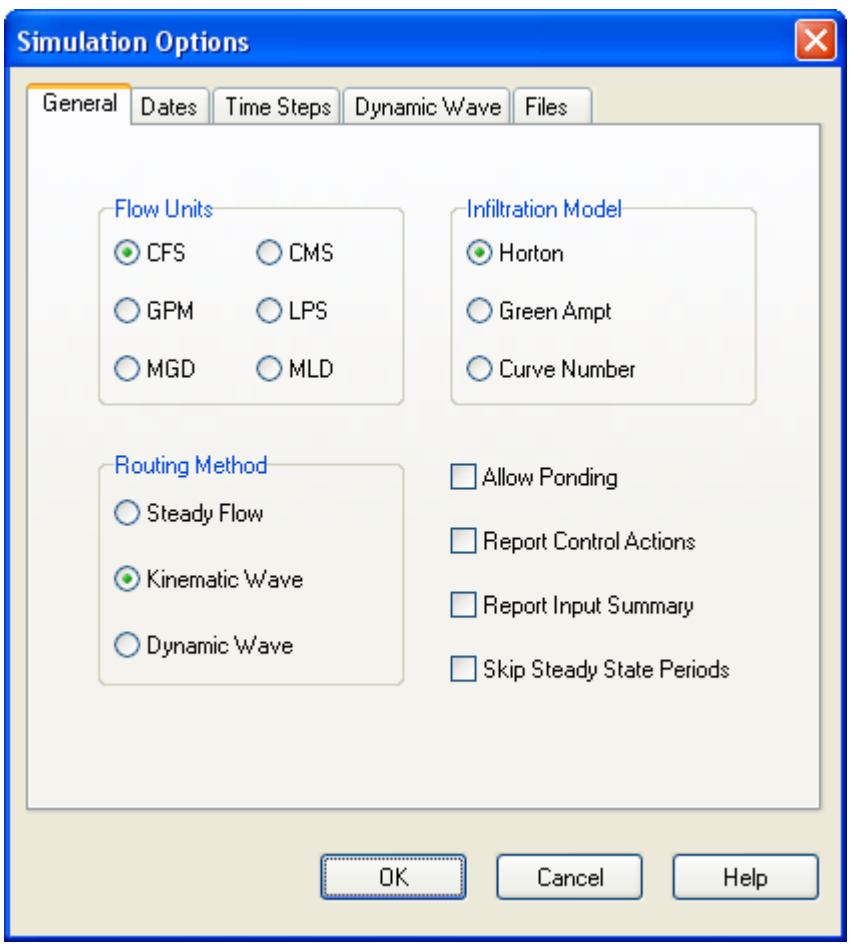
CHAPTER 8 - RUNNING A SIMULATION

After a study area has been suitably described, its runoff response, flow routing and water quality behavior can be simulated. This section describes how to specify options to be used in the analysis, how to run the simulation and how to troubleshoot common problems that might occur.

8.1 Setting Simulation Options

SWMM has a number of options that control how the simulation of a stormwater drainage system is carried out. To set these options:

1. Select the Options category from the Data Browser and then click the button.
2. A Simulation Options dialog will appear where you can make selections for the following categories of options:



- General Options
- Date Options
- Time Step Options
- Dynamic Wave Routing Options
- Interface File Options

3. When finished with the dialog, click the **OK** button to accept your choices or the **Cancel** button to cancel them.

The following sections discuss each category of options.

General Options

The General page of the Simulation Options dialog sets values for the following options:

Flow Units
Six choices of flow units are available. Selecting a US flow unit means that all other quantities will be expressed in US units, while choosing a metric flow unit will force all quantities to be expressed in metric units (see Appendix A.1). Units on previously entered data are not automatically adjusted if the unit system is changed.

Infiltration Model
This option controls how infiltration of rainfall into the upper soil zone of subcatchments is modeled. The choices are:
- Horton
- Green-Ampt
- Curve Number

Changing this option will require re-entering values for the infiltration parameters in each subcatchment.

Routing Method
This option determines which method is used to route flows through the conveyance system. The choices are:
- Steady Flow
- Kinematic Wave
- Dynamic Wave

Allow Ponding
Checking this option will allow excess water to collect atop nodes and be re-introduced into the system as conditions permit. In order for ponding to actually occur at a particular node, a non-zero value for its Ponded Area attribute must be used.

Report Control Actions
Check this option if you want the simulation's Status Report to list all control actions taken by the Control Rules associated with a project. This option should only be used for short-term simulation.

Report Input Summary
Check this option if you want the simulation's Status Report to list a summary of the project's input data.

Skip Steady State Periods
Checking this option will make the simulation use the most recently computed conveyance system flows during a steady state period instead of computing a new flow routing solution. A time step is considered to be in steady state if there has been no significant change in external inflows, storage volumes, and either node water depths (for dynamic wave routing) or conduit flows (for other forms of routing).

Date Options

The Dates page of the Simulation Options dialog determines the starting and ending dates/times of a simulation.

Start Analysis On
Enter the date (month/day/year) and time of day when the simulation begins.

Start Reporting On
Enter the date and time of day when reporting of simulation results is to begin. This must be on or after the simulation starting date and time.

End Analysis On
Enter the date and time when the simulation is to end.

Start Sweeping On
Enter the day of the year (month/day) when street sweeping operations begin. The default is January 1.

End Sweeping On
Enter the day of the year (month/day) when street sweeping operations end. The default is December 31.

Antecedent Dry Days
Enter the number of days with no rainfall prior to the start of the simulation. This value is used to compute an initial buildup of pollutant load on the surface of subcatchments.

If rainfall or climate data are read from external files, then the simulation dates should be set to coincide with the dates recorded in these files.

Time Step Options

The Time Steps page of the Simulation Options dialog establishes the length of the time steps used for runoff computation, routing computation and results reporting. Time steps are specified in days and hours:minutes:seconds except for flow routing which is entered as decimal seconds.

Reporting Time Step
Enter the time interval for reporting of computed results.

Runoff - Wet Weather Time Step
Enter the time step length used to compute runoff from subcatchments during periods of rainfall or when ponded water still remains on the surface.

Runoff - Dry Weather Time Step
Enter the time step length used for runoff computations (consisting essentially of pollutant buildup) during periods when there is no rainfall and no ponded water. This must be greater or equal to the Wet Weather time step.

Routing Time Step
Enter the time step length in decimal seconds used for routing flows and water quality constituents through the conveyance system. Note that Dynamic Wave routing requires a much smaller time step than the other methods of flow routing.

Dynamic Wave Options

The Dynamic Wave page of the Simulation Options dialog sets several parameters that control how the dynamic wave flow routing computations are made. These parameters have no effect for the other flow routing methods.

Inertial Terms
Indicates how the inertial terms in the St. Venant momentum equation will be handled.
- **KEEP** maintains these terms at their full value under all conditions.
- **DAMPEN** reduces the terms as flow comes closer to being critical and ignores them when flow is supercritical.
- **IGNORE** drops the terms altogether from the momentum equation, producing what is essentially a Diffusion Wave solution.

Use Normal Flow Limit
Selects which condition is used to make SWMM limit the flow in a conduit to the normal flow computed from the Manning equation:
- the water surface slope is less than the conduit slope
- the Froude number at either end of the conduit is greater than 1.0 (i.e., the flow is supercritical)

Use Variable Time Step
Indicates whether or not a variable time step should be used. The variable step is computed for each time period so as to satisfy the Courant stability criterion for each conduit and to prevent an excessive change in water depth at each node.

Safety Factor
This is a safety factor, between 10 and 200%, which is applied to the variable time step computed from the Courant criterion. It only applies when the Variable Time Step option is checked.

Time Step for Conduit Lengthening
This is a time step, in seconds, used to artificially lengthen conduits so that they meet the Courant stability criterion under full-flow conditions (i.e., the travel time of a wave will not be smaller than the specified conduit lengthening time step). As this value is decreased, fewer conduits will require lengthening. A value of 0 means that no conduits

will be lengthened. The ratio of the artificial length to the original length for each conduit is listed in the Conduit Flow Summary Table that appears in the simulation's Status Report (see Section 9.1).

Minimum Surface Area

This is a minimum surface area used at nodes when computing changes in water depth. If 0 is entered, then the default value of 12.566 ft^2 (1.167 m^2) is used. This is the area of a 4-ft diameter manhole. The value entered should be in square feet for US units or square meters for SI units.

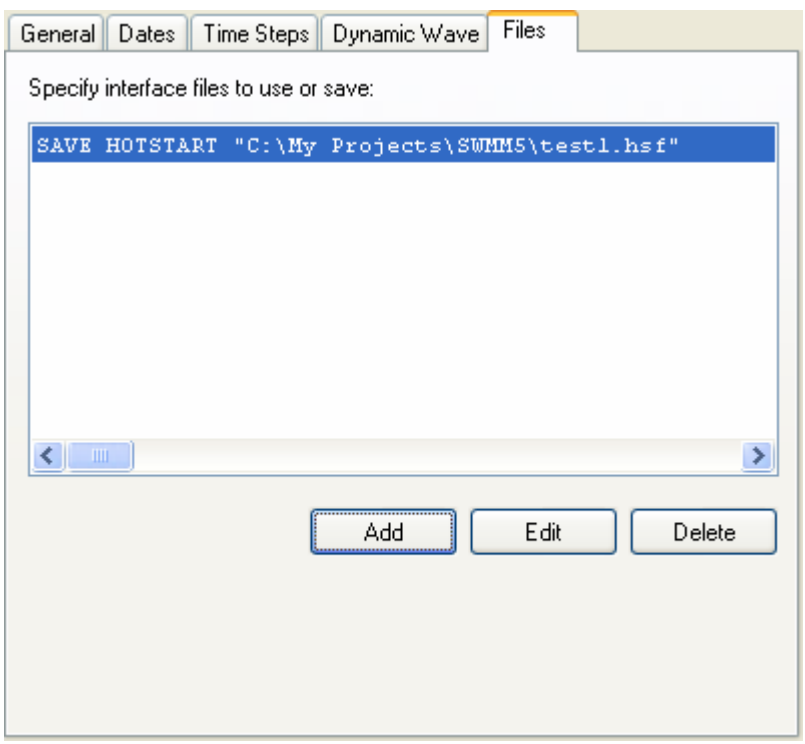
File Options

The Interface Files page of the Simulation Options dialog is used to specify which interface files will be used or saved during the simulation. (Interface files are described in Chapter 11.) The page contains a list box with three buttons underneath it. The list box lists the currently selected files, while the buttons are used as follows:

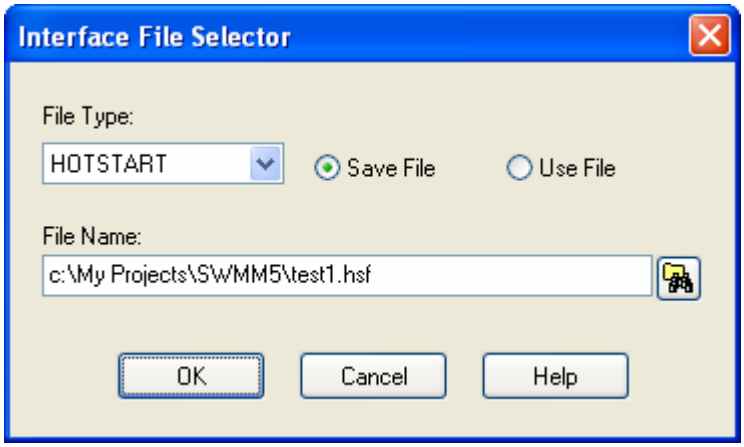
Add adds a new interface file specification to the list.

Edit edits the properties of the currently selected interface file.

Delete deletes the currently selected interface from the project (but not from your hard drive).



When the **Add** or **Edit** buttons are clicked, an Interface File Selection dialog appears where you can specify the type of interface file, whether it should be used or saved, and its name. The entries on this dialog are as follows:



File Type
Select the type of interface file to be specified.

Use / Save Buttons
Select whether the named interface file will be used to supply input to a simulation run or whether simulation results will be saved to it.

File Name
Enter the name of the interface file.

Browse Button
Click this button to launch a standard file selection dialog from which the path and name of the interface file can be selected.

8.2 Starting a Simulation

To start a simulation run either select **Project >> Run Simulation** from the Main Menu or click on the Standard Toolbar. A Run Status window will appear which displays the progress of the simulation.

To stop a run before its normal termination, click the **Stop** button on the Run Status window or press the <**Esc**> key. Simulation results up until the time when the run was stopped will be available for viewing. To minimize the SWMM program while a simulation is running, click the **Minimize** button on the Run Status window.

If the analysis runs successfully the icon will appear in the Run Status section of the Status Bar at the bottom of SWMM's main window. Any error or warning messages will appear in a Status Report window. If you modify the project after a successful run has been made, the faucet icon changes to a broken faucet indicating that the current computed results no longer apply to the modified project.

8.3 Troubleshooting Results

When a run ends prematurely, the Run Status dialog will indicate the run was unsuccessful and direct the user to the Status Report for details. The Status Report will include an error statement, code, and description of the problem (e.g., ERROR 138: Node TG040 has initial depth greater than maximum depth). Consult Appendix E for a description of SWMM's error messages. The following are the most common reasons for a run to end prematurely or to contain questionable results.

<u>Unknown ID Error Message</u>

This message typically appears when an object references another object that was never defined. An example would be a subcatchment whose outlet was designated as N29, but no such subcatchment or node with that name exists. Similar situations can exist for incorrect references made to Curves, Time Series, Time Patterns, Aquifers, Snow Packs, Transects, Pollutants, and Land Uses.

<u>File Errors</u>

File errors can occur when:

- a file cannot be located on the user's computer
- a file being used has the wrong format

- a file being written cannot be opened because the user does not have write privileges for the directory (folder) where the file is to be stored.

SWMM needs to have write privileges for a directory (folder) where temporary files are stored during a run. The original default is the directory where Windows writes its temporary files. If this directory does not exist or the user does not have write privileges to it, then a new directory must be assigned by using the Program Preferences dialog, which is discussed in Section 4.9.

Drainage System Layout Errors

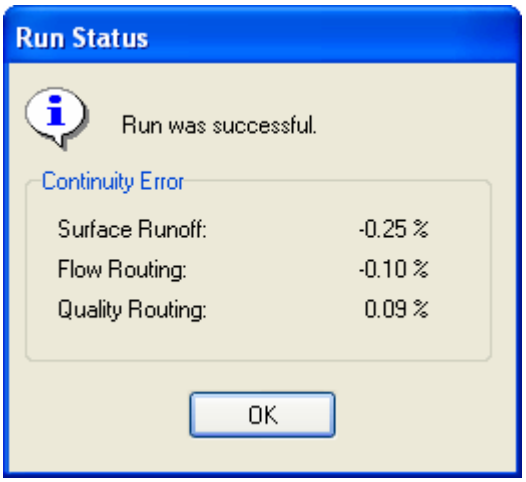
A valid drainage system layout must obey the following conditions:

- An outfall node can have only one conduit link connected to it.
- A flow divider node must have exactly two outflow links.
- Under Kinematic Wave routing, a junction node can only have one outflow link and a regulator link cannot be the outflow link of a non-storage node.
- Under Dynamic Wave routing there must be at least one outfall node in the network.

An error message will be generated if any of these conditions are violated.

Excessive Continuity Errors

When a run completes successfully, the mass continuity errors for runoff, flow routing, and pollutant routing will be displayed in the Run Status window. These errors represent the percent difference between initial storage plus total inflow and final storage plus total outflow for the entire drainage system. If they exceed some reasonable level, such as 10 percent, then the validity of the analysis results must be questioned. The most common reasons for an excessive continuity error are computational time steps that are too long or conduits that are too short.



In addition to the system continuity error, the Status Report produced by a run (see Section 9.1) will list those nodes of the drainage network that have the largest flow continuity errors. If the error for a node is excessive, then one should first consider if the node in question is of importance to the purpose of the simulation. If it is, then further study is warranted to determine how the error might be reduced.

Unstable Flow Routing Results

Due to the explicit nature of the numerical methods used for Dynamic Wave routing (and to a lesser extent, Kinematic Wave routing), the flows in some links or water depths at some nodes may fluctuate or oscillate significantly at certain periods of time as a result of

numerical instabilities in the solution method. SWMM does not automatically identify when such conditions exist, so it is up to the user to verify the numerical stability of the model and to determine if the simulation results are valid for the modeling objectives. Time series plots at key locations in the network can help identify such situations as can a scatter plot between a link's flow and the corresponding water depth at its upstream node (see Section 9.4, Viewing Results with a Graph).

Numerical instabilities can occur over short durations and may not be apparent when time series are plotted with a long time interval. When detecting such instabilities, it is recommended that a reporting time step of 1 minute or less be used, at least for an initial screening of results.

Numerical instabilities under Dynamic Wave flow routing can be reduced by:

- reducing the routing time step
- utilizing the variable time step option with a smaller time step factor
- selecting to ignore the inertial terms of the momentum equation
- selecting the option to lengthen short conduits.

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CHAPTER 9 - VIEWING RESULTS

This chapter describes the different ways in which the results of a simulation can be viewed. These include a status report, various map views, graphs, tables, and a statistical frequency report.

9.1 Viewing a Status Report

A Status Report is available for viewing after each simulation. It contains:

- a list of any error conditions encountered during the run
- a summary listing of the project's input data (if asked for in the Simulation Options)
- a summary of the data read from each rainfall file used in the simulation
- a description of each control rule action taken during the simulation (if asked for in the Simulation Options)
- the system-wide mass continuity errors for:
  - runoff quantity and quality
  - groundwater flow
  - conveyance system flow and water quality
- a Subcatchment Runoff Summary table that lists the following for each subcatchment:
  - total precipitation (in or mm)
  - total run-on from other subcatchments (in or mm)
  - total evaporation (in or mm)
  - total infiltration (in or mm)
  - total runoff (in or mm)
  - runoff coefficient (ratio of total runoff to total precipitation)
- a Node Depth Summary table that lists the following for each conveyance system node:
  - average water depth (ft or m)
  - maximum water depth (ft or m)
  - maximum hydraulic head (HGL) elevation (ft or m)
  - the elapsed time until when the maximum water depth occurred
  - total volume of flooding expressed as either inches per acre or as mm per hectare
  - total minutes flooded
- a Conduit Flow Summary table that lists the following for each conduit:
  - the maximum flow (flow units)
  - the elapsed time until when the maximum flow occurred
  - the maximum flow velocity (ft/sec or m/sec)
  - the ratio of the equivalent length of the conduit used in the simulation to its original length
  - the ratio of the maximum flow to the conduit's design flow (i.e., full normal flow)

        - the total minutes that the conduit was surcharged (either flowed full or had flow greater than the full normal flow)

- a Flow Classification Summary table (for dynamic wave routing only) that lists the following for each conduit:
    - the fraction of the time that the conduit was in each of the following flow categories:
        - dry on both ends
        - dry on the upstream end
        - dry on the downstream end
        - subcritical flow
        - supercritical flow
        - critical flow at the upstream end
        - critical flow at the downstream end
    - the average Froude number of the flow
    - the average change in flow over all time steps (expressed in flow units)

- the names of the five nodes with the highest individual flow continuity errrors

- the names of the five nodes or conduits that most often determined the size of the time step used for flow routing (only when the Variable Time Step option is used)

- information on the range of routing time steps taken and the percentage of these that were considered steady state.

To view the Status Report, select **Report >> Status** from the Main Menu.

To copy selected text from the Status Report to a file or to the Windows Clipboard, first select the text to copy with the mouse and then choose **Edit >> Copy To** from the Main Menu (or press the button on the Standard Toolbar). If the entire report is to be copied then it is not necessary to first select text with the mouse.

To locate an object that is listed in one of the Status Report's tables, first select the object's name with the mouse and choose **Edit >> Find** from the Main Menu (or press the button on the Standard Toolbar). Then in the Map Finder dialog that appears, select the type of object to look for (Subcatchment, Node or Link) and press the **Go** button (the object's name will have already been entered in the form). The object will appear highlighted in both the Data Browser and on the Study Area Map.

9.2 Variables That Can be Viewed

Computed results for the following variables are available for viewing on the map and can be plotted, tabulated, and statistically analyzed:

Subcatchment Variables

- rainfall rate (in/hr or mm/hr)
- snow depth (inches or millimeters)
- losses (infiltration + evaporation in in/hr or mm/hr)
- runoff flow (flow units)
- groundwater flow into the drainage network (flow units)
- groundwater elevation (ft or m)
- washoff concentration of each pollutant (mass/liter)

Link Variables

- flow rate (flow units)
- average water depth (ft or m)
- flow velocity (ft/sec or m/sec)
- Froude number (dimensionless)
- capacity (ratio of depth to full depth)
- concentration of each pollutant (mass/liter)

Node Variables

- water depth (ft or m above the node invert elevation)
- hydraulic head (ft or m, absolute elevation per vertical datum)
- water volume held in storage (including ponded water, ft^3 or m^3)
- lateral inflow (runoff + all other external inflows, in flow units)
- total inflow (lateral inflow + upstream inflows, in flow units)
- surface flooding (inflows lost from the system when the water depth exceeds the defined maximum node depth, flow units)
- concentration of each pollutant after any treatment (mass/liter)

System-Wide Variables

- air temperature (degrees F or C)
- total rainfall (in/hr or mm/hr)
- total snow depth (inches or millimeters)
- average losses (in/hr or mm/hr)
- total runoff flow (flow units)
- total dry weather inflow (flow units)
- total groundwater inflow (flow units)
- total I&I inflow (flow units)
- total direct inflow (flow units)
- total external inflow (flow units)
- total surface flooding (flow units)
- total outflow from outfalls (flow units)
- total nodal storage volume (ft3 or m3)

9.3 Viewing Results on the Map

There are several ways to view the values of certain input parameters and simulation results directly on the Study Area Map:

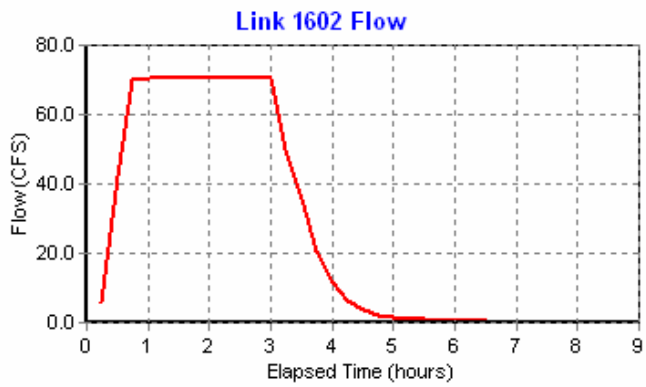
- For the current settings on the Map Browser, the subcatchments, nodes and links of the map will be colored according to their respective Map Legends. The map's color coding will be updated as a new time period is selected in the Map Browser.
- When the Flyover Map Labeling program preference is selected (see Section 4.9), moving the mouse over any map object will display its ID name and the value of its current theme parameter in a hint-style box.
- ID names and parameter values can be displayed next to all subcatchments, nodes and/or links by selecting the appropriate options on the Annotation page of the Map Options dialog (see Section 7.11).
- Subcatchments, nodes or links meeting a specific criterion can be identified by submitting a Map Query (see Section 7.8).

- You can animate the display of results on the network map either forward or backward in time by using the controls on the Animator Toolbar (see Section 4.3).
- The map can be printed, copied to the Windows clipboard, or saved as a DXF file or Windows metafile (see Section 7.12).

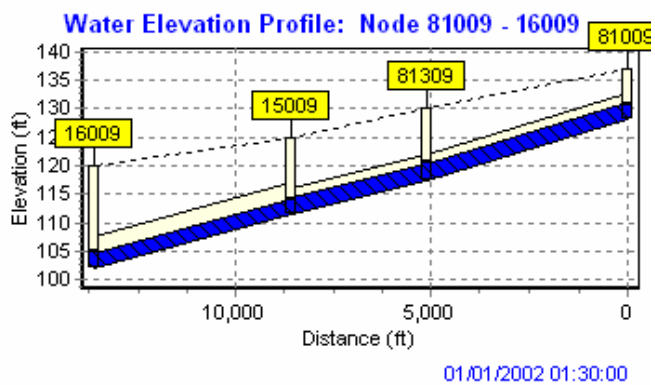
9.4 Viewing Results with a Graph

Analysis results can be viewed using several different types of graphs. Graphs can be printed, copied to the Windows clipboard, or saved to a text file or to a Windows metafile. The following types of graphs can be created from available simulation results:

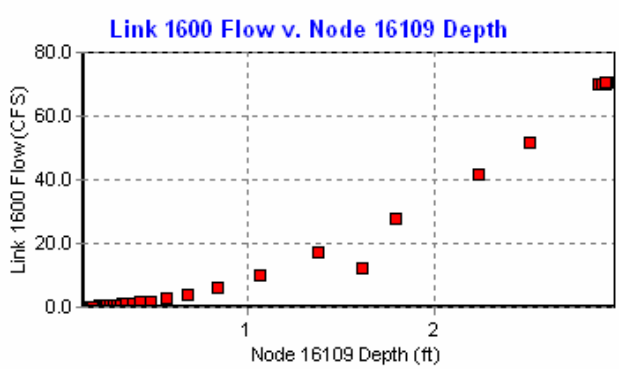
- Time Series Plot:



- Profile Plot:



- Scatter Plot:



The user can zoom in or out of any graph by holding down the <**Shift**> key while drawing a zoom rectangle with the mouse's left button held down. Drawing the rectangle from left to right zooms in, drawing from right to left zooms out. The plot can also be panned in any direction by holding down the <**Ctrl**> key and moving the mouse across the plot with the left button held down

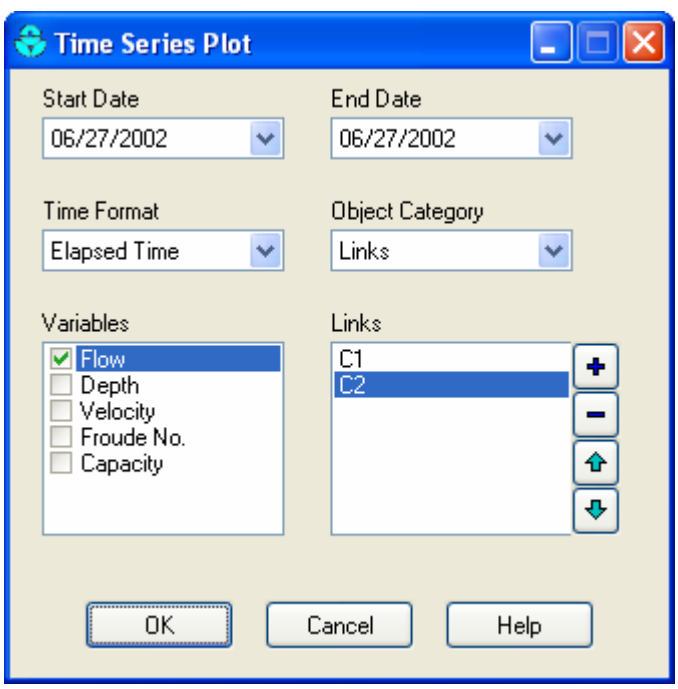
An opened graph will normally be redrawn when a new simulation is run. To prevent the automatic updating of a graph once a new set of results is computed the user can lock the current graph by clicking the icon in the upper left corner of the graph. To unlock the graph, click the icon again.

Time Series Plots

A Time Series Plot graphs the value of a particular variable at up to six locations against time. When only a single location is plotted, and that location has calibration data registered for the plotted variable, then the calibration data will be plotted along with the simulated results (see Section 5.5 for instructions on how to register calibration data with a project).

To create a Time Series Plot:

1. Select **Report >> Graph** from the Main Menu or click on the Standard Toolbar
2. Select **Time Series** from the sub-menu that appears.
3. A Time Series Plot dialog will appear. Use it to describe what objects and quantities should be plotted.



The Time Series Plot dialog describes the objects and variable to be graphed in a time series plot. Time series for certain system-wide variables, such as total rainfall, total runoff, total flooding, etc., can also be plotted. Use the dialog as follows:

1. Select a **Start Date** and **End Date** for the plot (the default is the entire simulation period).
2. Choose whether to show time as **Elapsed Time** or as **Date/Time** values.
3. Choose an **Object Category** (Subcatchment, Node, Link, or System) for plotting.
4. If the object category is not System, identify the objects to plot by:
   a. selecting the object either on the Study Area Map or in the Data Browser
   b. clicking the button on the dialog to add it to the plot,
   c. repeating these steps for any additional objects of the same category.
5. Select a simulated variable to be plotted. The available choices depend on the category of object selected.
6. Click the **OK** button to create the plot.

A maximum of 6 objects can be selected for a single plot. Objects already selected can be deleted, moved up in the order or moved down in the order by clicking the , , and buttons, respectively.

Profile Plots

A Profile Plot displays the variation in simulated water depth with distance over a connected path of drainage system links and nodes at a particular point in time. Once the plot has been created it will be automatically updated as a new time period is selected using the Map Browser and the Animator toolbar.

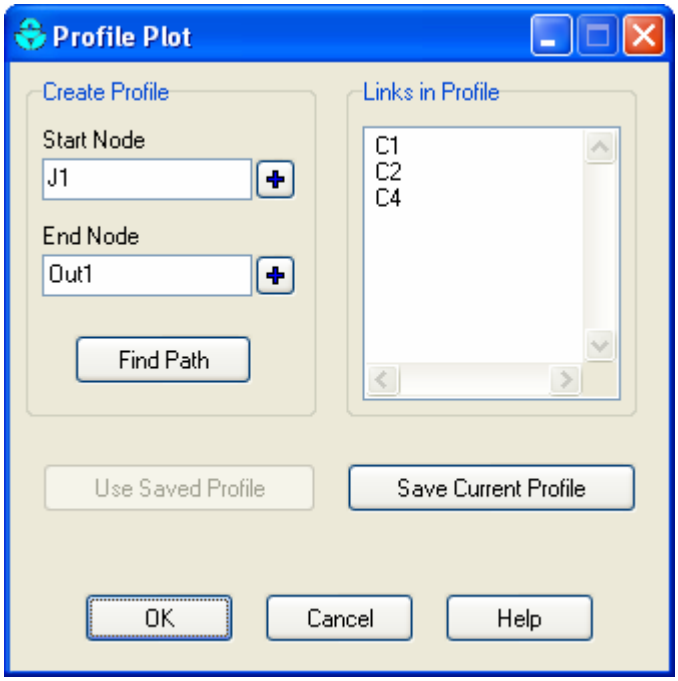
To create a Profile Plot:

1. Select **Report >> Graph** from the main menu or press on the Standard Toolbar
2. Select **Profile** from the sub-menu that appears.
3. A Profile Plot dialog will appear. Use it to identify the path along which the profile plot is to be drawn.

The Profile Plot dialog is used to specify a path of connected conveyance system links along which a water depth profile versus distance should be drawn. To define a path using the dialog:

1. Enter the ID of the upstream node of the first link in the path in the **Start Node** edit field (or click on the node on the Study Area Map and then on the button next to the edit field).
2. Enter the ID of the downstream node of the last link in the path in the **End Node** edit field (or click the node on the map and then click the button next to the edit field).

3. Click the **Find Path** button to have the program automatically identify the path of links between the start and end nodes. These will be listed in the **Links in Profile** box.
4. You can edit the entries in the **Links in Profile** if need be, using one link per line.
5. Click the **OK** button to view the profile plot.

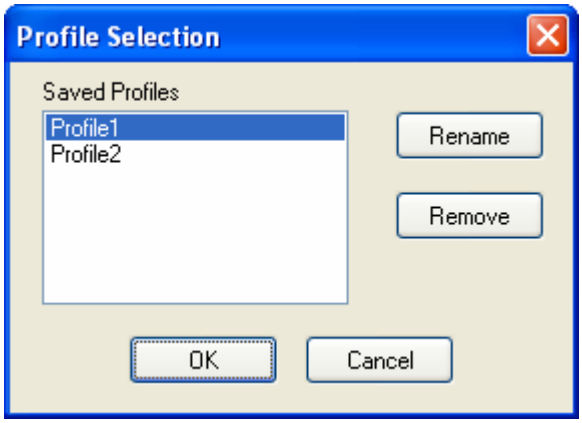


To save the current set of links listed in the dialog for future use:

1. Click the **Save Current Profile** button.
2. Supply a name for the profile when prompted.

To use a previously saved profile:

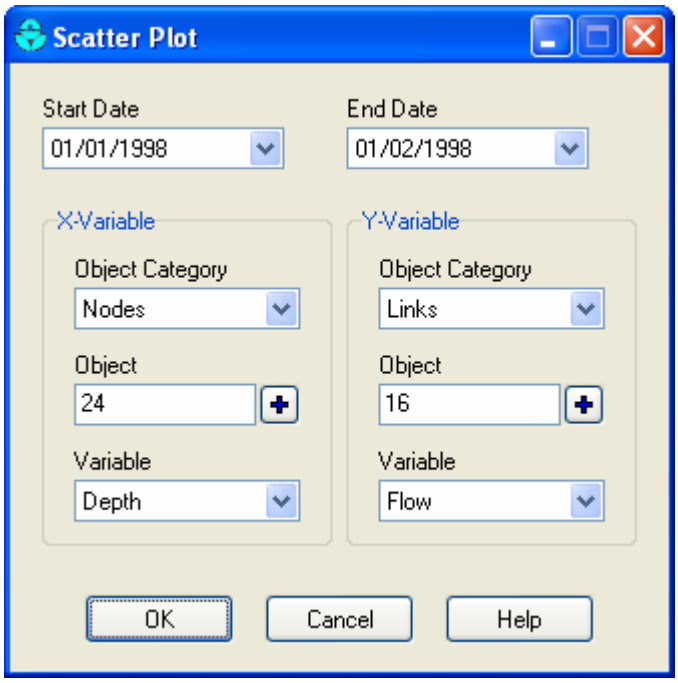
1. Click the **Use Saved Profile** button.
2. Select the profile to use from the Profile Selection dialog that appears.



Scatter Plots

A Scatter Plot displays the relationship between a pair of variables, such as flow rate in a pipe versus water depth at a node. To create a Scatter Plot:

1. Select **Report >> Graph** from the main menu or press on the Standard Toolbar
2. Select **Scatter** from the sub-menu that appears.
3. Specify what time interval and what pair of objects and their variables to plot using the Scatter Plot dialog that appears.



The Scatter Plot dialog is used to select the objects and variables to be graphed against one another in a scatter plot. Use the dialog as follows:

1. Select a **Start Date** and **End Date** for the plot (the default is the entire simulation period).
2. Select the following choices for the **X-variable** (the quantity plotted along the horizontal axis):
   - **Object Category** (Subcatchment, Node or Link)
   - **Object ID** (enter a value or click on the object either on the Study Area Map or in the Data Browser and then click the button on the dialog)
   - **Variable** to plot (choices depend on the category of object selected).
3. Do the same for the **Y-variable** (the quantity plotted along the vertical axis).
4. Click the **OK** button to create the plot.

9.5 Customizing a Graph's Appearance

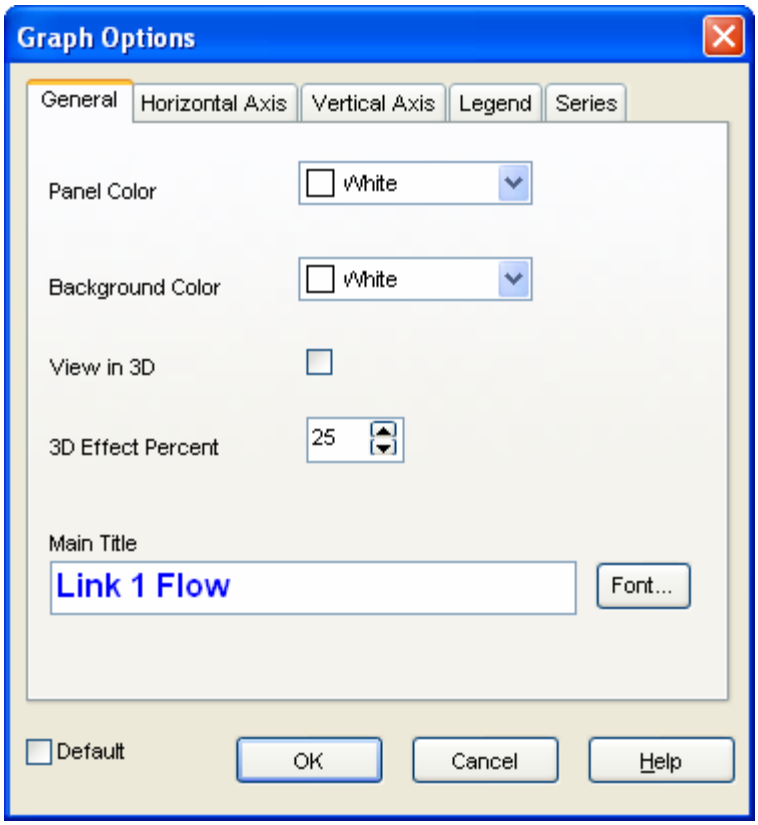
To customize the appearance of a graph:

1. Make the graph the active window (click on its title bar).
2. Select **Report >> Options** from the Main Menu, or click on the Standard Toolbar, or right-click on the graph.
3. Use the Graph Options dialog that appears to customize the appearance of a Time Series or Scatter Plot, or use the Profile Plot Options dialog for a Profile Plot.

Graph Options Dialog

The Graph Options dialog is used to customize the appearance of a time series plot or a scatter plot. To use the dialog:

1. Select from among the five tabbed pages that cover the following categories of options: General , Horizontal Axis, Vertical Axis, Legend, and Series.
2. Check the **Default** box if you wish to use the current settings as defaults for all new graphs as well.
3. Select **OK** to accept your selections.



Graph Options - General

The following options can be set on the General page of the Graph Options dialog box:

Panel Color	Color of the panel that contains the graph
Background Color	Color of graph's plotting area
View in 3D	Check if graph should be drawn in 3D
3D Effect Percent	Degree to which 3D effect is drawn
Main Title	Text of graph's main title
Font	Click to set the font used for the main title

Graph Options - Axes

The Horizontal Axis and Vertical Axis pages of the Graph Options dialog box adjust the way that the axes are drawn on a graph.

Minimum	Sets minimum axis value (minimum data value is shown in parentheses). Can be left blank.
Maximum	Sets maximum axis value (maximum data value is shown in parentheses). Can be left blank.
Increment	Sets increment between axis labels. Can be left blank.
Auto Scale	If checked then Minimum, Maximum, and Increment settings are ignored.
Gridlines	Toggles the display of grid lines on and off.
Axis Title	Text of axis title.
Font	Click to select a font for the axis title.

Graph Options - Legend

The Legend page of the Graph Options dialog box controls how the legend is displayed on the graph.

Position	Selects where to place the legend.
Color	Selects color to use for legend background.
Symbol Width	Selects width to use (in pixels) to draw the symbol portion of the legend.
Framed	Places a frame around the legend.
Visible	Makes the legend visible.

Graph Options - Series

The Series page of the Graph Options dialog box controls how individual data series (or curves) are displayed on a graph. To use this page:

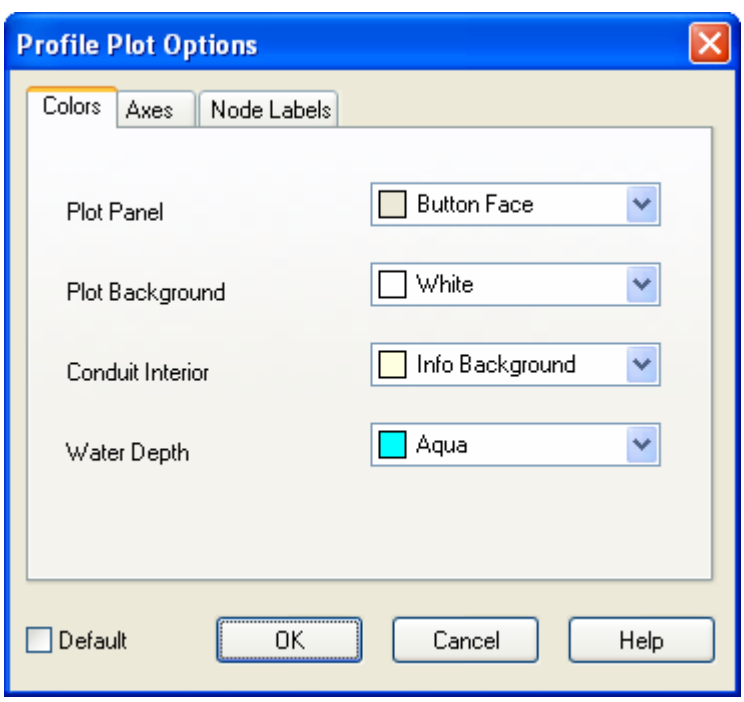
1. Select a data series to work with from the **Series** combo box.
2. Edit the title used to identify this series in the legend.
3. Click the **Font** button to change the font used for the legend. (Other legend properties are selected on the Legend page of the dialog.)

4. Select a property of the data series you would like to modify (not all properties are available for some types of graphs). The choices are:
   - Lines
   - Markers
   - Patterns
   - Labels

Profile Plot Options Dialog

The Profile Plot Options dialog is used to customize the appearance of a Profile Plot. The dialog contains three pages:

1. Colors: selects the color to use for the plot window panel, the plot background, a conduit's interior, and the depth of filled water.
2. Axes:
   - edits the main and axis titles, including their fonts
   - selects to display horizontal and vertical axis grid lines.
3. Node Labels:
   - Selects to display node ID labels either along the plot's top axis, directly on the plot above the node's crown height, or both.
   - Selects the length of arrow to draw between the node label and the node's crown on the plot (use 0 for no arrows).
   - Selects the font size of the node ID labels.



Check the **Default** box if you want these options to apply to all new profile plots when they are first created.

9.6 Viewing Results with a Table

Time series results for selected variables and objects can also be viewed in a tabular format. There are two types of formats available:

- **Table by Object** - tabulates the time series of several variables for a single object (e.g., flow and water depth for a conduit).

Table - Link 7

Date	Time	Flow (CFS)	Depth (ft)
01/01/1998	01:00:00	0.00	0.00
01/01/1998	02:00:00	2.58	0.40
01/01/1998	03:00:00	4.87	0.55
01/01/1998	04:00:00	5.41	0.58
01/01/1998	05:00:00	5.23	0.57
01/01/1998	06:00:00	1.74	0.33

- **Table by Variable** - tabulates the time series of a single variable for several objects of the same type (e.g., runoff for a group of subcatchments).

Table - Subcatch Runoff

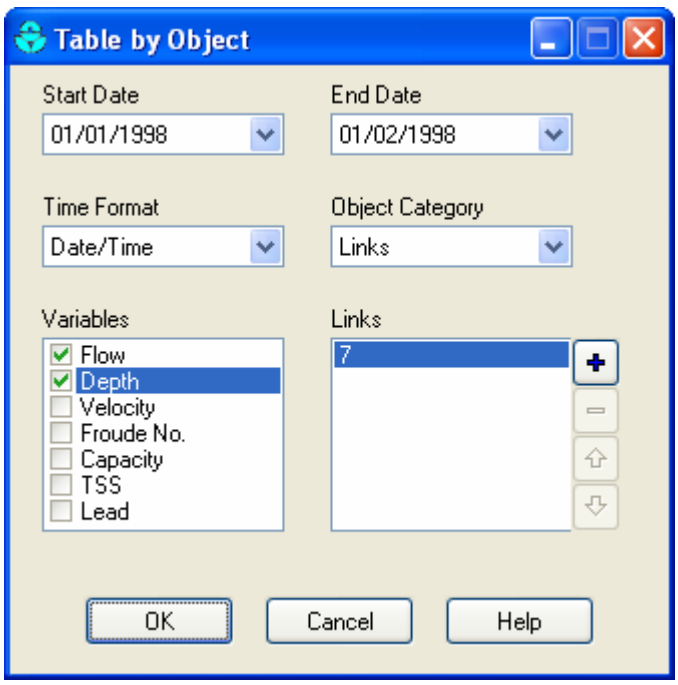
Date	Time	Subcatch 2	Subcatch 5
01/01/1998	01:00:00	0.00	0.00
01/01/1998	02:00:00	1.24	1.81
01/01/1998	03:00:00	2.56	3.82
01/01/1998	04:00:00	4.52	6.56
01/01/1998	05:00:00	2.51	3.59
01/01/1998	06:00:00	0.70	1.03

To create a tabular report:

1. Select **Report >> Table** from the Main Menu or click on the Standard Toolbar.
2. Choose the table format (either **By Object** or **By Variable**) from the sub-menu that appears.
3. Fill in the Table by Object or Table by Variable dialogs to specify what information the table should contain.

The Table by Object dialog is used when creating a time series table of several variables for a single object. Use the dialog as follows:

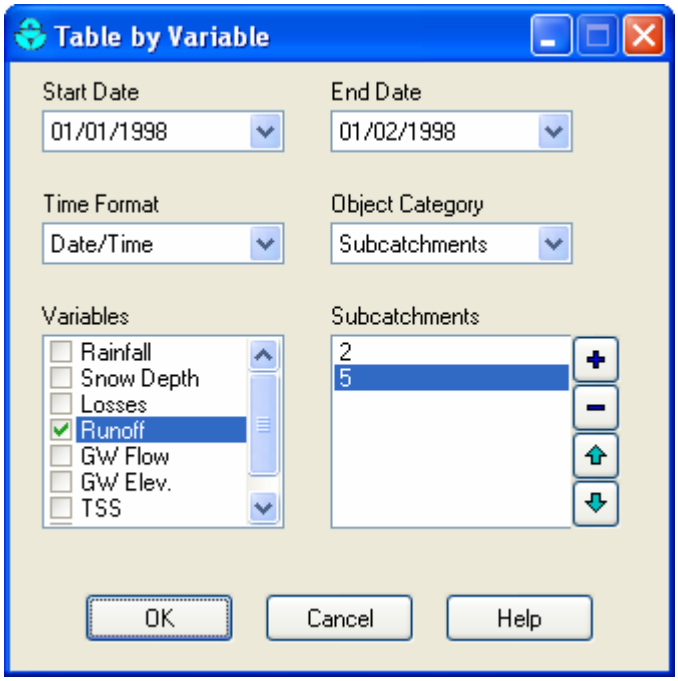
1. Select a **Start Date** and **End Date** for the table (the default is the entire simulation period).
2. Choose whether to show time as **Elapsed Time** or as **Date/Time** values.
3. Choose an **Object Category** (Subcatchment, Node, Link, or System).
4. Identify a specific object in the category by clicking the object either on the Study Area Map or in the Data Browser and then clicking the button on the dialog. Only a single object can be selected for this type of table.
5. Check off the variables to be tabulated for the selected object. The available choices depend on the category of object selected.
6. Click the **OK** button to create the table.



The Table by Variable dialog is used when creating a time series table of a single variable for one or more objects. Use the dialog as follows:

1. Select a **Start Date** and **End Date** for the table (the default is the entire simulation period).
2. Choose whether to show time as **Elapsed Time** or as **Date/Time** values.
3. Choose an **Object Category** (Subcatchment, Node or Link).
4. Select a simulated variable to be tabulated. The available choices depend on the category of object selected.
5. Identify one or more objects in the category by successively clicking the object either on the Study Area Map or in the Data Browser and then clicking the button on the dialog.

6. Click the **OK** button to create the table.



A maximum of 6 objects can be selected for a single table. Objects already selected can be deleted, moved up in the order or moved down in the order by clicking the , , and buttons, respectively.

9.7 Viewing a Statistics Report

A Statistics Report can be generated from the time series of simulation results. For a given object and variable this report will do the following:

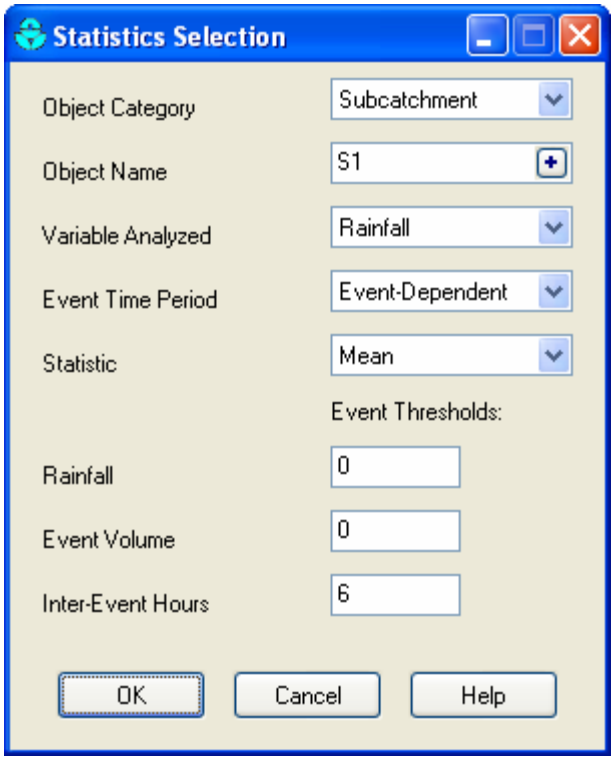
- segregate the simulation period into a sequence of non-overlapping events, either by day, month, or by flow (or volume) above some minimum threshold value,
- compute a statistical value that characterizes each event, such as the mean, maximum, or total sum of the variable over the event's time period,
- compute summary statistics for the entire set of event values (mean, standard deviation and skewness),
- perform a frequency analysis on the set of event values.

The frequency analysis of event values will determine the frequency at which a particular event value has occurred and will also estimate a return period for each event value. Statistical analyses of this nature are most suitable for long-term continuous simulation runs.

To generate a Statistics Report:

1. Select **Report >> Statistics** from the Main Menu or click Σ on the Standard Toolbar.
2. Fill in the Statistics Selection dialog that appears, specifying the object, variable, and event definition to be analyzed.

The **Statistics Selection** dialog is used to define the type of statistical analysis to be made on a computed simulation result. It contains the following data fields:



Object Category
Selects the category of object to analyze (Subcatchment, Node, Link or System).

Object Name
Specifies the ID name of the object to analyze.

Variable Analyzed
Specifies the name of the variable to be analyzed. The choices depend on the object category selected (e.g., rainfall, losses, or runoff for subcatchments; depth, inflow, or overflow for nodes; depth, flow, velocity, or capacity for links; water quality for all categories).

Event Time Period
Sets the length of the time period that defines an event. The choices are daily, monthly, or event-dependent. In the latter case, the event period depends on the number of

consecutive reporting periods where simulation results are above the threshold values defined below.

Statistic
Selects the event statistic to be analyzed. The available choices depend on the choice of variable to be analyzed and include such quantities as mean value, peak value, event total, event duration, and time between events. For water quality variables the choices include mean concentration, peak concentration, mean loading, peak loading, and event total load.

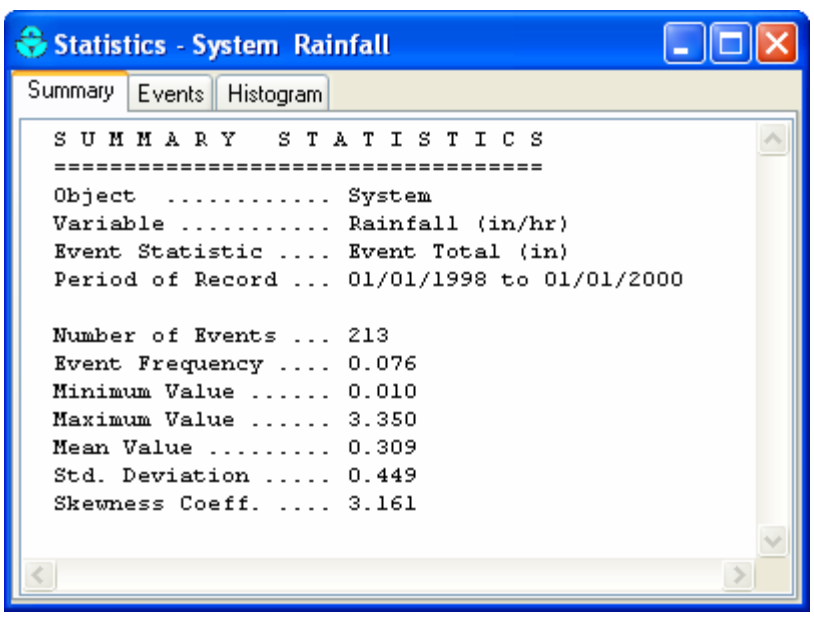
Analysis Variable Threshold
Sets the minimum value of the variable being analyzed that must be exceeded for a time period to be included in an event.

Event Volume Threshold
Sets the minimum flow volume (or rainfall volume) that must be exceeded for a result to be counted as part of an event. Enter 0 if no volume threshold applies.

Inter-Event Hours
Sets the minimum number of hours that must occur between two separate events. Events with fewer hours are combined together. This value applies only to event-dependent time periods (not to daily or monthly event periods).

The Statistics Report consists of three tabbed pages that contain:

- a table of event summary statistics
- a table of rank-ordered event periods, including their date, duration, and magnitude
- a histogram plot of the chosen event statistic.



CHAPTER 10 - PRINTING AND COPYING

This chapter describes how to print, copy to the Windows clipboard, or copy to file the contents of the currently active window in the SWMM workspace. This can include the study area map, a graph, a table, or a report.

10.1 Selecting a Printer

To select a printer from among your installed Windows printers and set its properties:

1. Select **File >> Page Setup** from the Main Menu.
2. Click the **Printer** button on the Page Setup dialog that appears (see Figure 10-1).
3. Select a printer from the choices available in the combo box in the Print Setup dialog that appears.
4. Click the **Properties** button to select the appropriate printer properties (which vary with choice of printer).
5. Click **OK** on each dialog to accept your selections.

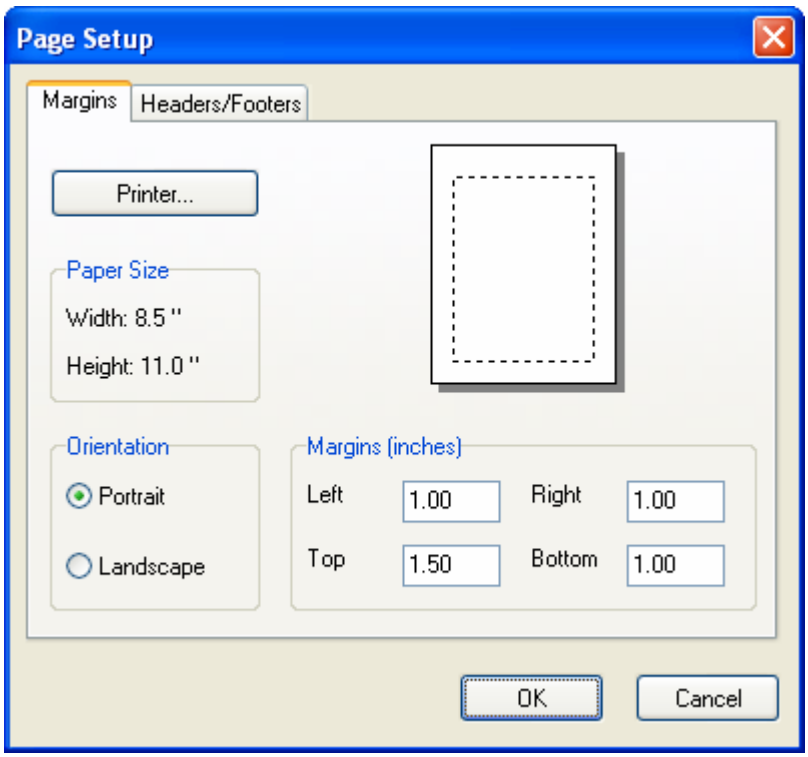


Figure 10-1. The Margins page of the Page Setup dialog.

10.2 Setting the Page Format

To format the printed page:

1. Select **File >> Page Setup** from the main menu.
2. Use the Margins page of the Page Setup dialog form that appears (Figure 10-1) to:
   - Select a printer.
   - Select the paper orientation (Portrait or Landscape).
   - Set left, right, top, and bottom margins.
3. Use the Headers/Footers page of the dialog box (Figure 10-2) to:
   - Supply the text for a header that will appear on each page.
   - Indicate whether the header should be printed or not and how its text should be aligned.
   - Supply the text for a footer that will appear on each page.
   - Indicate whether the footer should be printed or not and how its text should be aligned.
   - Indicate whether pages should be numbered.
4. Click **OK** to accept your choices.

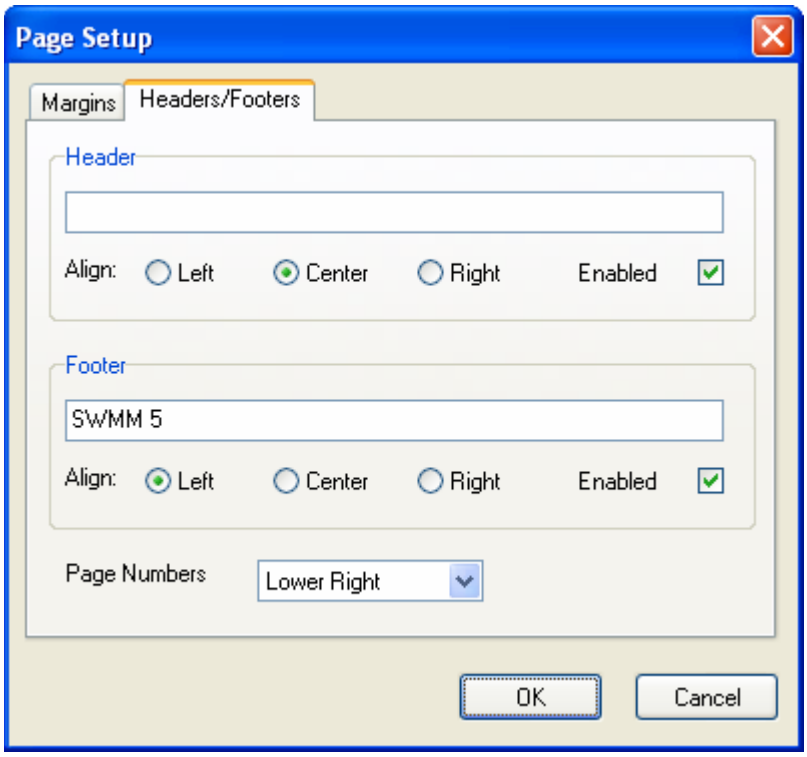


Figure 10-2. The Headers/Footers page of the Page Setup dialog.

10.3 Print Preview

To preview a printout, select **File >> Print Preview** from the Main Menu. A Preview form will appear which shows how each page being printed will appear. While in preview mode, the left mouse button will re-center and zoom in on the image and the right mouse button will re-center and zoom out.

10.4 Printing the Current View

To print the contents of the current window being viewed in the SWMM workspace either select **File >> Print** from the Main Menu or click on the Standard Toolbar. The following views can be printed:

- Study Area Map (at the current zoom level)
- Status Report.
- Graphs (Time Series, Profile, and Scatter plots)
- Tabular Reports
- Statistical Reports.

10.5 Copying to the Clipboard or to a File

SWMM can copy the text and graphics of the current window being viewed to the Windows clipboard or to a file. Views that can be copied in this fashion include the Study Area Map, graphs, tables, and reports. To copy the current view to the clipboard or to file:

1. If the current view is a table, select the cells of the table to copy by dragging the mouse over them or copy the entire table by selecting **Edit >> Select All** from the Main Menu.
2. Select **Edit >> Copy To** from the Main Menu or click the button on the Standard Toolbar.
3. Select choices from the Copy dialog (see Figure 10-3) that appears and click the **OK** button.
4. If copying to file, enter the name of the file in the **Save As** dialog that appears and click **OK**.

Use the Copy dialog as follows to define how you want your data copied and to where:

1. Select a destination for the material being copied (Clipboard or File)
2. Select a format to copy in:
   Bitmap (graphics only)

Metafile (graphics only)
Data (text, selected cells in a table, or data used to construct a graph)

3. Click **OK** to accept your selections or **Cancel** to cancel the copy request.

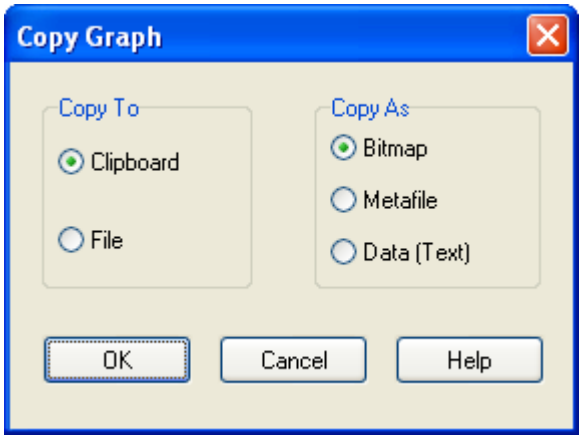


Figure 10-3. Example of the Copy dialog.

CHAPTER 11 - FILES USED BY SWMM

This section describes the various files that SWMM can utilize. They include: the project file, the report and output files, rainfall files, the climate file, calibration data files, time series files, and interface files. The only file required to run SWMM is the project file; the others are optional.

11.1 Project Files

A SWMM project file is a plain text file that contains all of the data used to describe a study area and the options used to analyze it. The file is organized into sections, where each section generally corresponds to a particular category of object used by SWMM. The contents of the file can be viewed from within SWMM while it is open by selecting **Project >> Details** from the Main Menu. An existing project file can be opened by selecting **File >> Open** from the Main Menu and be saved by selecting **File >> Save** (or **File >> Save As**).

Normally a SWMM user would not edit the project file directly, since SWMM's graphical user interface can add, delete, or modify a project's data and control settings. However, for large projects where data currently reside in other electronic formats, such as CAD or GIS files, it may be more expeditious to extract data from these sources and save it to a formatted project file before running SWMM. The format of the project file is described in detail in Appendix D of this manual.

After a project file is saved to disk, a settings file will automatically be saved with it. This file has the same name as the project file except that its extension is **.ini** (e.g., if the project file were named **project1.inp** then its settings file would have the name **project1.ini**). It contains various settings used by SWMM's graphical user interface, such as map display options, legend colors and intervals, object default values, and calibration file information. Users should not edit this file. A SWMM project will still load and run even if the settings file is missing.

11.2 Report and Output Files

The report file is a plain text file created after every SWMM run that contains a status report on the results of a run. It can be viewed by selecting **Report >> Status** from the main menu. If the run was unsuccessful it will contain a list of error messages. For a successful run it will contain:

- the mass continuity errors for runoff quantity and quality as well as for flow and water quality routing,
- summary results tables for all drainage system nodes and links, and
- frequency distributions of time step size and iterations required when Dynamic Wave routing analyses are performed.

The output file is a binary file that contains the numerical results from a successful SWMM run. This file is used by SWMM's user interface to interactively create time series plots and tables, profile plots, and statistical analyses of a simulation's results.

Whenever a successfully run project is closed (either by opening or creating a new project or by exiting SWMM), the user is asked if the current results should be saved. If the answer is yes, then the report and output files are saved with the same name as the project file, but with extensions of **.rpt** and **.out**, respectively. The next time that the project is opened, the results from these files will automatically be available for viewing.

If a project's data were modified before a successful run was made, then when the project is closed the user is asked if the updated project should be saved or not. If the answer is no, then results of the most recent run will not be saved either.

11.3 Rainfall Files

SWMM's rain gage objects can utilize rainfall data stored in external rainfall files. The program currently recognizes the following formats for storing such data:

- **DSI-3240** and related formats which record hourly rainfall at U.S. National Weather Service (NWS) and Federal Aviation Agency stations, available online from the National Climatic Data Center (NCDC) at www.ncdc.noaa.gov/oa/ncdc.html.
- **DSI-3260** and related formats which record fifteen minute rainfall at NWS stations, also available online from NCDC.
- **HLY03** and **HLY21** formats for hourly rainfall at Canadian stations, available online from Environment Canada at www.climate.weatheroffice.ec.gc.ca.
- **FIF21** format for fifteen minute rainfall at Canadian stations, also available online from Environment Canada.
- a standard user-prepared format where each line of the file contains the station ID, year, month, day, hour, minute, and non-zero precipitation reading, all separated by one or more spaces.

An excerpt from a sample user-prepared Rainfall file is as follows:

```
STA01  2004  6  12  00  00  0.12
STA01  2004  6  12  01  00  0.04
STA01  2004  6  22  16  00  0.07
```

When a rain gage is designated as receiving its rainfall data from a file, the user must supply the name of the file and the name of the recording station referenced in the file. For the standard user-prepared format, the rainfall type (e.g., intensity or volume), recording time interval, and depth units must also be supplied as rain gage properties. For the other file types these properties are defined by their respective file format and are automatically recognized by SWMM.

11.4 Climate Files

SWMM can use an external climate file that contains daily air temperature, evaporation, and wind speed data. The program currently recognizes the following formats:

- A **DSI-3200** or **DSI-3210** file available from the National Climatic Data Center at www.ncdc.noaa.gov/oa/ncdc.html.
- Canadian climate files available from Environment Canada at www.climate.weatheroffice.ec.gc.ca.
- A user-prepared climate file where each line contains a recording station name, the year, month, day, maximum temperature, minimum temperature, and optionally, evaporation rate, and wind speed. If no data are available for any of these items on a given date, then an asterisk should be entered as its value.

When a climate file has days with missing values, SWMM will use the value from the most recent previous day with a recorded value.

For a user-prepared climate file, the data must be in the same units as the project being analyzed. For US units, temperature is in degrees F, evaporation is in inches/day, and wind speed is in miles/hour. For metric units, temperature is in degrees C, evaporation is in mm/day, and wind speed is in km/hour.

11.5 Calibration Files

Calibration files contain measurements of variables at one or more locations that can be compared with simulated values in Time Series Plots. Separate files can be used for each of the following:

- Subcatchment Runoff
- Subcatchment Pollutant Washoff
- Node Depth
- Node Inflow
- Node Water Quality
- Link Flow

Calibration files are registered to a project by selecting **Project >> Calibration Data** from the main menu (see Section 5.5).

The format of the file is as follows:

1. The name of the first object with calibration data is entered on a single line.
2. Subsequent lines contain the following recorded measurements for the object:
   - measurement date (month/day/year, e.g., 6/21/2004) or number of whole days since the start of the simulation
   - measurement time (hours:minutes) on the measurement date or relative to the number of elapsed days
   - measurement value (for pollutants, a value is required for each pollutant).
3. Follow the same sequence for any additional objects.

An excerpt from an example calibration file is shown below. It contains flow values for two conduits: 1030 and 1602. Note that a semicolon can be used to begin a comment and also in this example, elapsed time rather than the actual measurement date was used.

```
;Flows for Selected Conduits
;Conduit  Days  Time  Flow
;-----------------------------
 1030
           0     0:15  0
           0     0:30  0
           0     0:45  23.88
           0     1:00  94.58
           0     1:15  115.37
 1602
           0     0:15  5.76
           0     0:30  38.51
           0     1:00  67.93
           0     1:15  68.01
```

11.6 Time Series Files

Time series files are external text files that contain data for SWMM's time series objects. Examples of time series data include rainfall, evaporation, inflows to nodes of the drainage system, and water stage at outfall boundary nodes. Normally these data are entered and edited through SWMM's Time Series Editor dialog. However there is an option to import data from an external file into the editor. Creating and editing this file can be done outside of SWMM, using text editors or spreadsheet programs.

The format of a time series file consists of two lines of descriptive text followed by the actual time series data, with one time series value per line. Typically, the first text line identifies the time series and the second line includes a detailed description of the time series. Time series values can either be in **date / time / value** format or in **time / value** format, where each entry is separated by one or more spaces or tab characters. For the **date / time / value** format, dates are entered as month/day/year (e.g., 7/21/2004) and times as 24-hour military time (e.g., 8:30 pm is 20:30). After the first date, additional dates need only be entered whenever a new day occurs. For the **time / value** format, time can either be decimal hours or military time since the start of a simulation (e.g., 2 days, 4 hours and 20 minutes can be entered as either 52.333 or 52:20). An example of a time series file is shown below:

When preparing rainfall time series files, it is only necessary to enter periods with non-zero rainfall amounts. SWMM interprets the rainfall value as a constant value lasting over the recording interval specified for the rain gage which utilizes the time series. For all other types of time series, SWMM uses interpolation to estimate values at times that fall in between the recorded values.

```
EPASWMM Time Series Data
<optional description goes here>
07/01/2003  00:00 0.00000
            00:15 0.03200
            00:30 0.04800
            00:45 0.02400
            01:00 0.0100
07/06/2003  14:30 0.05100
            14:45 0.04800
            15:00 0.03000
            18:15 0.01000
            18:30 0.00800
```

11.7 Interface Files

SWMM can use several different kinds of interface files that contain either externally imposed inputs (e.g., rainfall or infiltration/inflow hydrographs) or the results of previously run analyses (e.g., runoff or routing results). These files can help speed up simulations, simplify comparisons of different loading scenarios, and allow large study areas to be broken up into smaller areas that can be analyzed individually. The different types of interface files that are currently available include:

- rainfall interface file
- runoff interface file
- hotstart file
- RDII interface file
- routing interface files

Consult Section 8.1, *Setting Simulation Options,* for instructions on how to specify interface files for use as input and/or output in a simulation.

Rainfall and Runoff Files

The rainfall and runoff interface files are binary files created internally by SWMM that can be saved and reused from one analysis to the next.

The rainfall interface file collates a series of separate rain gage files into a single rainfall data file. Normally a temporary file of this type is created for every SWMM analysis that uses external rainfall data files and is then deleted after the analysis is completed. However, if the same rainfall data are being used with many different analyses, requesting SWMM to save the rainfall interface file after the first run and then reusing this file in subsequent runs can save computation time.

The rainfall interface file should not be confused with a rainfall data file. The latter are external text files that provide rainfall time series data to rain gages. The former is a binary file created internally by SWMM that processes the rainfall data files used by a project.

The runoff interface file can be used to save the runoff results generated from a simulation run. If runoff is not affected in future runs, the user can request that SWMM use this interface file to supply runoff results without having to repeat the runoff calculations again.

Hotstart Files

Hotstart files are binary files created by SWMM that contain hydraulic and water quality variables for the drainage system at the end of a run. These data consist of the water depth and concentration of each pollutant at each node of the system as well as the flow rate and concentration of each pollutant in each link. The hotstart file saved after a run can be used to define the initial conditions for a subsequent run.

Hotstart files can be used to avoid the initial numerical instabilities that sometimes occur under Dynamic Wave routing. For this purpose they are typically generated by imposing a constant set of base flows (for a natural channel network) or set of dry weather sanitary flows (for a sewer network) over some startup period of time. The resulting hotstart file from this run is then used to initialize a subsequent run where the inflows of real interest are imposed.

It is also possible to both use and save a hotstart file in a single run, starting off the run with one file and saving the ending results to another. The resulting file can then serve as the initial conditions for a subsequent run if need be. This technique can be used to divide up extremely long continuous simulations into more manageable pieces.

RDII Files

The RDII interface file is a text file that contains a time series of rainfall-derived infiltration/inflow flows for a specified set of drainage system nodes. This file can be generated from a previous SWMM run when Unit Hydrographs and nodal RDII inflow data have been defined for the project, or it can be created outside of SWMM using some other source of RDII data (e.g., through measurements or output from a different computer program). The format of the file is the same as that of the routing interface file discussed below, where Flow is the only variable contained in the file.

Routing Files

A routing interface file stores a time series of flows and pollutant concentrations that are discharged from the outfall nodes of drainage system model. This file can serve as the source of inflow to another drainage system model that is connected at the outfalls of the first system. A **Combine** utility is available on the **File** menu that will combine pairs of routing interface files into a single interface file. This allows very large systems to be broken into smaller sub-systems that can be analyzed separately and linked together through the routing interface file. Figure 11-1 below illustrates this concept.

A single SWMM run can utilize an outflows routing file to save results generated at a system's outfalls, an inflows routing file to supply hydrograph and pollutograph inflows at selected nodes, or both.

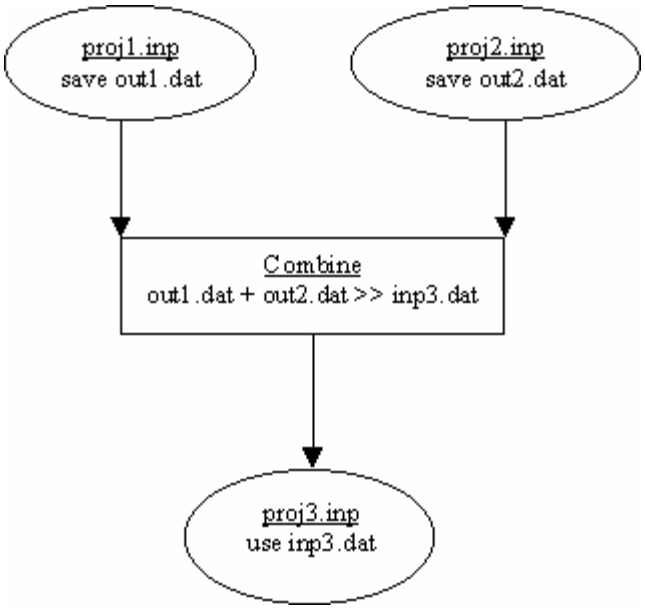


Figure 11-1. Example of using the Combine utility to merge Routing files together.

RDII / Routing File Format

RDII interface files and routing interface files have the same text format:

- the first line contains the keyword "SWMM5" (without the quotes)
- a line of text that describes the file (can be blank)
- the time step used for all inflow records (integer seconds)
- the number of variables stored in the file, where the first variable must always be flow rate
- the name and units of each variable (one per line), where flow rate is the first variable listed and is always named FLOW
- the number of nodes with recorded inflow data
- the name of each node (one per line)
- a line of text that provides column headings for the data to follow (can be blank)
- for each node at each time step, a line with:
  1. the name of the node
  2. the date (year, month, and day separated by spaces)
  3. the time of day (hours, minutes, and seconds separated by spaces)
  4. the flow rate followed by the concentration of each quality constituent

Time periods with no values at any node can be skipped. An excerpt from an RDII / routing interface file is shown below.

```
SWMM5
Example File
300
1
FLOW CFS
2
N1
N2
Node Year Mon Day Hr Min Sec Flow
N1   2002 04  01  00 20  00  0.000000
N2   2002 04  01  00 20  00  0.002549
N1   2002 04  01  00 25  00  0.000000
N2   2002 04  01  00 25  00  0.002549
```

APPENDIX A - USEFUL TABLES

A.1 Units of Measurement

PARAMETER	US CUSTOMARY	SI METRIC
Area (Subcatchment)	acres	Hectares
Area (Storage Unit)	square feet	square meters
Area (Ponding)	square feet	square meters
Capillary Suction	inches	millimeters
Concentration	mg/L ug/L Count/L	mg/L ug/L Count/L
Decay Constant (Infiltration)	1/hours	1/hours
Decay Constant (Pollutants)	1/days	1/days
Depression Storage	inches	millimeters
Depth	feet	meters
Diameter	feet	meters
Discharge Coefficient Orifice Weir	 dimensionless CFS/foot^n	 dimensionless CMS/meter^n
Elevation	feet	meters
Evaporation	inches/day	millimeters/day
Flow	CFS GPM MGD	CMS LPS MLD
Head	feet	meters
Hydraulic Conductivity	inches/hour	millimeters/hour
Infiltration Rate	inches/hour	millimeters/hour
Length	feet	meters
Manning's n	seconds/meter$^{1/3}$	seconds/meter$^{1/3}$
Pollutant Buildup	mass/length mass/acre	mass/length mass/hectare
Rainfall Intensity	inches/hour	millimeters/hour
Rainfall Volume	inches	millimeters
Slope (Subcatchments)	percent	percent
Slope (Cross Section)	rise/run	rise/run
Street Cleaning Interval	days	days
Volume	cubic feet	cubic meters
Width	feet	meters

A.2 Soil Characteristics

Soil Texture Class	K	Ψ	ϕ	FC	WP
Sand	4.74	1.93	0.437	0.062	0.024
Loamy Sand	1.18	2.40	0.437	0.105	0.047
Sandy Loam	0.43	4.33	0.453	0.190	0.085
Loam	0.13	3.50	0.463	0.232	0.116
Silt Loam	0.26	6.69	0.501	0.284	0.135
Sandy Clay Loam	0.06	8.66	0.398	0.244	0.136
Clay Loam	0.04	8.27	0.464	0.310	0.187
Silty Clay Loam	0.04	10.63	0.471	0.342	0.210
Sandy Clay	0.02	9.45	0.430	0.321	0.221
Silty Clay	0.02	11.42	0.479	0.371	0.251
Clay	0.01	12.60	0.475	0.378	0.265

K = saturated hydraulic conductivity, in/hr
Ψ = suction head, in.
ϕ = porosity, fraction
FC = field capacity, fraction
WP= wilting point, fraction

Source: Rawls, W.J. et al., (1983). *J. Hyd. Engr.*, 109:1316.

A.3 NRCS Hydrologic Soil Group Definitions

Group	Meaning	Saturated Hydraulic Conductivity (in/hr)
A	Low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels.	≥ 0.45
B	Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures. E.g., shallow loess, sandy loam.	0.30 - 0.15
C	Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures. E.g., clay loams, shallow sandy loam.	0.15 - 0.05
D	High runoff potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay-pan or clay layer at or near the surface, and shallow soils over nearly impervious material.	0.05 - 0.00

A.4 SCS Curve Numbers[1]

	Hydrologic Soil Group			
Land Use Description	**A**	**B**	**C**	**D**
Cultivated land				
Without conservation treatment	72	81	88	91
With conservation treatment	62	71	78	81
Pasture or range land				
Poor condition	68	79	86	89
Good condition	39	61	74	80
Meadow				
Good condition	30	58	71	78
Wood or forest land				
Thin stand, poor cover, no mulch	45	66	77	83
Good cover[2]	25	55	70	77
Open spaces, lawns, parks, golf courses, cemeteries, etc.				
Good condition: grass cover on 75% or more of the area	39	61	74	80
Fair condition: grass cover on 50-75% of the area	49	69	79	84
Commercial and business areas (85% impervious)	89	92	94	95
Industrial districts (72% impervious)	81	88	91	93
Residential[3]				
Average lot size (% Impervious[4])				
1/8 ac or less (65)	77	85	90	92
1/4 ac (38)	61	75	83	87
1/3 ac (30)	57	72	81	86
1/2 ac (25)	54	70	80	85
1 ac (20)	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]	98	98	98	98
Streets and roads				
Paved with curbs and storm sewers[5]	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89

1. Antecedent moisture condition II; Source*: SCS Urban Hydrology for Small Watersheds*, 2nd Ed., (TR-55), June 1986.
2. Good cover is protected from grazing and litter and brush cover soil.
3. Curve numbers are computed assuming that the runoff from the house and driveway is directed toward the street with a minimum of roof water directed to lawns where additional infiltration could occur.
4. The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.
5. In some warmer climates of the country a curve number of 95 may be used.

A.5 Depression Storage

Impervious surfaces	0.05 - 0.10 inches
Lawns	0.10 - 0.20 inches
Pasture	0.20 inches
Forest litter	0.30 inches

Source: ASCE, (1992). *Design & Construction of Urban Stormwater Management Systems,* New York, NY.

A.6 Manning's n – Overland Flow

Surface	**n**
Smooth asphalt	0.011
Smooth concrete	0.012
Ordinary concrete lining	0.013
Good wood	0.014
Brick with cement mortar	0.014
Vitrified clay	0.015
Cast iron	0.015
Corrugated metal pipes	0.024
Cement rubble surface	0.024
Fallow soils (no residue)	0.05
Cultivated soils Residue cover < 20% Residue cover > 20%	 0.06 0.17
Range (natural)	0.13
Grass Short, prarie Dense Bermuda grass	 0.15 0.24 0.41
Woods Light underbrush Dense underbrush	 0.40 0.80

Source: McCuen, R. et al. (1996), *Hydrology*, FHWA-SA-96-067, Federal Highway Administration, Washington, DC

A.7 Manning's n – Closed Conduits

Conduit Material	Manning n
Asbestos-cement pipe	0.011 - 0.015
Brick	0.013 - 0.017
Cast iron pipe - Cement-lined & seal coated	 0.011 - 0.015
Concrete (monolithic) - Smooth forms - Rough forms	 0.012 - 0.014 0.015 - 0.017
Concrete pipe	0.011 - 0.015
Corrugated-metal pipe (1/2-in. x 2-2/3-in. corrugations) - Plain - Paved invert - Spun asphalt lined	 0.022 - 0.026 0.018 - 0.022 0.011 - 0.015
Plastic pipe (smooth)	0.011 - 0.015
Vitrified clay - Pipes - Liner plates	 0.011 - 0.015 0.013 - 0.017

Source: ASCE (1982). *Gravity Sanitary Sewer Design and Construction*, ASCE Manual of Practice No. 60, New York, NY.

A.8 Manning's n – Open Channels

Channel Type	Manning n
Lined Channels	
- Asphalt	0.013 - 0.017
- Brick	0.012 - 0.018
- Concrete	0.011 - 0.020
- Rubble or riprap	0.020 - 0.035
- Vegetal	0.030 - 0.40
Excavated or dredged	
- Earth, straight and uniform	0.020 - 0.030
- Earth, winding, fairly uniform	0.025 - 0.040
- Rock	0.030 - 0.045
- Unmaintained	0.050 - 0.140
Natural channels (minor streams, top width at flood stage < 100 ft)	
- Fairly regular section	0.030 - 0.070
- Irregular section with pools	0.040 - 0.100

Source: ASCE (1982). *Gravity Sanitary Sewer Design and Construction*, ASCE Manual of Practice No. 60, New York, NY.

A.9 Water Quality Characteristics of Urban Runoff

Constituent	Event Mean Concentrations
TSS (mg/L)	180 - 548
BOD (mg/L)	12 - 19
COD (mg/L)	82 - 178
Total P (mg/L)	0.42 - 0.88
Soluble P (mg/L)	0.15 - 0.28
TKN (mg/L)	1.90 - 4.18
NO2/NO3-N (mg/L)	0.86 - 2.2
Total Cu (ug/L)	43 - 118
Total Pb (ug/L)	182 - 443
Total Zn (ug/L)	202 - 633

Source: U.S. Environmental Protection Agency. (1983). *Results of the Nationwide Urban Runoff Program (NURP),* Vol. 1, NTIS PB 84-185552), Water Planning Division, Washington, DC.

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APPENDIX B - VISUAL OBJECT PROPERTIES

B.1 Rain Gage Properties

Name	User-assigned rain gage name.
X-Coordinate	Horizontal location of the rain gage on the Study Area Map. If left blank then the rain gage will not appear on the map.
Y-Coordinate	Vertical location of the rain gage on the Study Area Map. If left blank then the rain gage will not appear on the map.
Description	Optional description of the rain gage.
Tag	Optional label used to categorize or classify the rain gage.
Rain Format	Format in which the rain data are supplied: ***INTENSITY:*** each rainfall value is an average rate in inches/hour (or mm/hour) over the recording interval, ***VOLUME:*** each rainfall value is the volume of rain that fell in the recording interval (in inches or millimeters), ***CUMULATIVE:*** each rainfall value represents the cumulative rainfall that has occurred since the start of the last series of non-zero values (in inches or millimeters).
Rain Interval	Time interval between gage readings in either decimal hours or hours:minutes format.
Snow Catch Factor	Factor that corrects gage readings for snowfall.
Data Source	Source of rainfall data; either ***TIMESERIES*** for user-supplied time series data or ***FILE*** for an external data file.
TIME SERIES	
- Series Name	Name of time series with rainfall data if Data Source selection was ***TIMESERIES***; leave blank otherwise (double-click to edit the series).
DATA FILE	
- File Name	Name of external file containing rainfall data.
- Station No.	Recording gage station number.
- Rain Units	Depth units (**IN** or **MM**) for rainfall values in the file.

B.2 Subcatchment Properties

Name	User-assigned subcatchment name.
X-Coordinate	Horizontal location of the subcatchment's centroid on the Study Area Map. If left blank then the subcatchment will not appear on the map.
Y-Coordinate	Vertical location of the subcatchment's centroid on the Study Area Map. If left blank then the subcatchment will not appear on the map.
Description	Click the ellipsis button (or press Enter) to edit an optional description of the subcatchment.
Tag	Optional label used to categorize or classify the subcatchment.
Rain Gage	Name of the rain gage associated with the subcatchment.
Outlet	Name of the node or subcatchment which recieves the subcatchment's runoff.
Area	Area of the subcatchment (acres or hectares).
Width	Characteristic width of the overland flow path for sheet flow runoff (feet or meters). An initial estimate of the characteristic width is given by the subcatchment area divided by the average maximum overland flow length. The maximum overland flow length is the length of the flow path from the inlet to the furthest drainage point of the subcatchment. Maximum lengths from several different possible flow paths should be averaged. These paths should reflect slow flow, such as over pervious surfaces, more than rapid flow over pavement, for example. Adjustments should be made to the width parameter to produce good fits to measured runoff hydrographs.
% Slope	Average percent slope of the subcatchment.
% Imperv	Percent of land area which is impervious.
N-Imperv	Manning's n for overland flow over the impervious portion of the subcatchment (see Section A.6 for typical values).
N-Perv	Manning's n for overland flow over the pervious portion of the subcatchment (see Section A.6 for typical values).
Dstore-Imperv	Depth of depression storage on the impervious portion of the subcatchment (inches or millimeters) (see Section A.5 for typical values).
Dstore-Perv	Depth of depression storage on the pervious portion of the subcatchment (inches or millimeters) (see Section A.5 for typical values).
% Zero-Imperv	Percent of the impervious area with no depression storage.
Subarea Routing	Choice of internal routing of runoff between pervious and impervious areas: ***IMPERV***: runoff from pervious area flows to impervious area, ***PERV***: runoff from impervious area flows to pervious area, ***OUTLET***: runoff from both areas flows directly to outlet.

Percent Routed	Percent of runoff routed between subareas.
Infiltration	Click the ellipsis button (or press Enter) to edit infiltration parameters for the subcatchment.
Groundwater	Click the ellipsis button (or press Enter) to edit groundwater flow parameters for the subcatchment.
Snow Pack	Name of snow pack parameter set (if any) assigned to the subcatchment.
Initial Buildup	Click the ellipsis button (or press Enter) to specify initial quantities of pollutant buildup over the subcatchment.
Land Uses	Click the ellipsis button (or press Enter) to assign land uses to the subcatchment.
Curb Length	Total length of curbs in the subcatchment (any length units). Used only when pollutant buildup is normalized to curb length.

B.3 Junction Properties

Name	User-assigned junction name.
X-Coordinate	Horizontal location of the junction on the Study Area Map. If left blank then the junction will not appear on the map.
Y-Coordinate	Vertical location of the junction on the Study Area Map. If left blank then the junction will not appear on the map.
Description	Click the ellipsis button (or press Enter) to edit an optional description of the junction.
Tag	Optional label used to categorize or classify the junction.
Inflows	Click the ellipsis button (or press Enter) to assign time series, dry weather, or RDII inflows to the junction.
Treatment	Click the ellipsis button (or press Enter) to edit a set of treatment functions for pollutants entering the node.
Invert El.	Invert elevation of the junction (feet or meters).
Max. Depth	Maximum depth of junction (i.e., from ground surface to invert) (feet or meters).
Initial Depth	Depth of water at the junction at the start of the simulation (feet or meters).
Surcharge Depth	Additional depth of water beyond the maximum depth that is allowed before the junction floods (feet or meters). This parameter can be used to simulate bolted manhole covers.
Ponded Area	Area occupied by ponded water atop the junction after flooding occurs (sq. feet or sq. meters). If the Allow Ponding Simulation Option is turned on, a non-zero value of this parameter will allow ponded water to be stored and subsequently returned to the conveyance system when capacity exists.

B.4 Outfall Properties

Name	User-assigned outfall name.
X-Coordinate	Horizontal location of the outfall on the Study Area Map. If left blank then the outfall will not appear on the map.
Y-Coordinate	Vertical location of the outfall on the Study Area Map. If left blank then the outfall will not appear on the map.
Description	Click the ellipsis button (or press Enter) to edit an optional description of the outfall.
Tag	Optional label used to categorize or classify the outfall.
Inflows	Click the ellipsis button (or press Enter) to assign time series, dry weather, or RDII inflows to the outfall.
Treatment	Click the ellipsis button (or press Enter) to edit a set of treatment functions for pollutants entering the node.
Invert El.	Invert elevation of the outfall (feet or meters).
Tide Gate	***YES -*** tide gate present which prevents backflow ***NO -*** no tide gate present
Type	Type of outfall boundary condition: ***FREE****:* outfall stage determined by minimum of critical flow depth and normal flow depth in the connecting conduit ***NORMAL****:* outfall stage based on normal flow depth in connecting conduit ***FIXED****:* outfall stage set to a fixed value ***TIDAL****:* outfall stage given by a table of tide elevation versus time of day ***TIMESERIES****:* outfall stage supplied from a time series of elevations.
Fixed Stage	Water elevation for a ***FIXED*** type of outfall (feet or meters).
Tidal Curve Name	Name of the Tidal Curve relating water elevation to hour of the day for a ***TIDAL*** outfall (double-click to edit the curve).
Time Series Name	Name of time series containing time history of outfall elevations for a ***TIMESERIES*** outfall (double-click to edit the series).

B.5 Flow Divider Properties

Name	User-assigned divider name.
X-Coordinate	Horizontal location of the divider on the Study Area Map. If left blank then the divider will not appear on the map.
Y-Coordinate	Vertical location of the divider on the Study Area Map. If left blank then the divider will not appear on the map.
Description	Click the ellipsis button (or press Enter) to edit an optional description of the divider.
Tag	Optional label used to categorize or classify the divider.
Inflows	Click the ellipsis button (or press Enter) to assign time series, dry weather, or RDII inflows to the divider.
Treatment	Click the ellipsis button (or press Enter) to edit a set of treatment functions for pollutants entering the node.
Invert El.	Invert elevation of the divider (feet or meters).
Max. Depth	Maximum depth of divider (i.e., from ground surface to invert) (feet or meters).
Initial Depth	Depth of water at the divider at the start of the simulation (feet or meters).
Surcharge Depth	Additional depth of water beyond the maximum depth that is allowed before the junction floods (feet or meters). This parameter can be used to simulate bolted manhole covers.
Ponded Area	Area occupied by ponded water atop the junction after flooding occurs (sq. feet or sq. meters). If the Allow Ponding Simulation Option is turned on, a non-zero value of this parameter will allow ponded water to be stored and subsequently returned to the conveyance system when capacity exists.
Diverted Link	Name of link which receives the diverted flow.
Type	Type of flow divider. Choices are: ***CUTOFF*** (diverts all inflow above a defined cutoff value), ***OVERFLOW*** (diverts all inflow above the flow capacity of the non-diverted link), ***TABULAR*** (uses a Diversion Curve to express diverted flow as a function of the total inflow), ***WEIR*** (uses a weir equation to compute diverted flow).
CUTOFF DIVIDER	
- Cutoff Flow	Cutoff flow value used for a ***CUTOFF*** divider (flow units).
TABULAR DIVIDER	
- Curve Name	Name of Diversion Curve used with a ***TABULAR*** divider (double-click to edit the curve).

WEIR DIVIDER	
- Min. Flow	Minimum flow at which diversion begins for a ***WEIR*** divider (flow units).
- Max. Depth	Vertical height of **WEIR** opening (feet or meters)
- Coefficient	Product of **WEIR**'s discharge coefficient and its length. Weir coefficients are typically in the range of 2.65 to 3.10 per foot, for flows in CFS.

B.6 Storage Unit Properties

Name	User-assigned storage unit name.
X-Coordinate	Horizontal location of the storage unit on the Study Area Map. If left blank then the storage unit will not appear on the map.
Y-Coordinate	Vertical location of the storage unit on the Study Area Map. If left blank then the storage unit will not appear on the map.
Description	Click the ellipsis button (or press Enter) to edit an optional description of the storage unit.
Tag	Optional label used to categorize or classify the storage unit.
Inflows	Click the ellipsis button (or press Enter) to assign time series, dry weather, or RDII inflows to the storage unit.
Treatment	Click the ellipsis button (or press Enter) to edit a set of treatment functions for pollutants entering the storage unit.
Invert El.	Elevation of the bottom of the storage unit (feet or meters).
Max. Depth	Maximum depth of the storage unit (feet or meters).
Initial Depth	Initial depth of water in the storage unit at the start of the simulation (feet or meters).
Ponded Area	Surface area occupied by ponded water atop the storage unit once the water depth exceeds the maximum depth (sq. feet or sq. meters). If the **Allow Ponding** analysis option is turned on, a non-zero value of this parameter will allow ponded water to be stored and subsequently returned to the drainage system when capacity exists.
Evap. Factor	The fraction of the potential evaporation from the storage unit's water surface that is actually realized.
Shape Curve	Method of describing the geometric shape of the storage unit. ***FUNCTIONAL*** shape uses the function Area = A*(Depth)^B + C to describe how surface area varies with depth. ***TABULAR*** shape uses a tabulated area versus depth curve. In either case, depth is measured in feet (or meters) and surface area in sq. feet (or sq. meters).

FUNCTIONAL	
- Coeff.	A-value in the functional relationship between surface area and storage depth.
- Exponent	B-value in the functional relationship between surface area and storage depth.
- Constant	C-value in the functional relationship between surface area and storage depth.
TABULAR	
- Curve Name	Name of the Storage Curve containing the relationship between surface area and storage depth (double-click to edit the curve).

B.7 Conduit Properties

Name	User-assigned conduit name.
Inlet Node	Name of node on the inlet end of the conduit (which is normally the end at higher elevation).
Outlet Node	Name of node on the outlet end of the conduit (which is normally the end at lower elevation).
Description	Click the ellipsis button (or press Enter) to edit an optional description of the conduit.
Tag	Optional label used to categorize or classify the conduit.
Shape	Click the ellipsis button (or press Enter) to edit the geometric properties of the conduit's cross section.
Length	Conduit length (feet or meters).
Roughness	Manning's roughness coefficient (see Section A.7 for closed conduit values or Section A.8 for open channel values).
Inlet Offset	Height of the conduit invert above the node invert at the upstream end of the conduit (feet or meters).
Outlet Offset	Height of the conduit invert above the node invert at the downstream end of the conduit (feet or meters).
Initial Flow	Initial flow in the conduit at the start of the simulation (flow units).
Maximum Flow	Maximum flow allowed in the conduit under dynamic wave routing (flow units) – use 0 or leave blank if not applicable.
Entry Loss Coeff.	Head loss coefficient associated with energy losses at the entrance of the conduit.
Exit Loss Coeff.	Coefficient associated with energy losses at the exit of the conduit.
Avg. Loss Coeff.	Coefficient associated with energy losses along the length of the conduit.

Flap Gate	***YES*** if a flap gate exists which prevents backflow through the conduit, or ***NO*** if no flap gate exists.

B.8 Pump Properties

Name	User-assigned pump name.
Inlet Node	Name of node on the inlet side of the pump.
Outlet Node	Name of node on the outlet side of the pump.
Description	Click the ellipsis button (or press Enter) to edit an optional description of the pump.
Tag	Optional label used to categorize or classify the pump.
Pump Curve	Name of the Pump Curve which contains the pump's operating data (double-click to edit the curve).
Initial Status	Status of the pump (***ON*** or ***OFF***) at the start of the simulation.

B.9 Orifice Properties

Name	User-assigned orifice name.
Inlet Node	Name of node on the inlet side of the orifice.
Outlet Node	Name of node on the outlet side of the orifice.
Description	Click the ellipsis button (or press Enter) to edit an optional description of the orifice.
Tag	Optional label used to categorize or classify the orifice.
Type	Type of orifice (***SIDE*** or ***BOTTOM***).
Shape	Orifice shape (***CIRCULAR*** or ***RECT_CLOSED***).
Height	Height of orifice when fully open (feet or meters). Corresponds to the diameter of a circular orifice or the height of a rectangular orifice.
Width	Width of rectangular orifice when fully opened (feet or meters)
Crest Height	Height of bottom of orifice above invert of inlet node (feet or meters).
Discharge Coeff.	Discharge coefficient (unitless). A typical value is 0.65.
Flap Gate	***YES*** if a flap gate exists which prevents backflow through the orifice, or ***NO*** if no flap gate exists.

B.10 Weir Properties

Name	User-assigned weir name.
Inlet Node	Name of node on inlet side of weir.
Outlet Node	Name of node on outlet side of weir.
Description	Click the ellipsis button (or press Enter) to edit an optional description of the weir.
Tag	Optional label used to categorize or classify the weir.
Type	Weir type: **TRANSVERSE**, **SIDEFLOW**, **V-NOTCH**, or **TRAPEZOIDAL**
Height	Vertical height of weir opening (feet or meters)
Length	Horizontal length of weir opening (feet or meters)
Side Slope	Slope (width-to-height) of side walls for a ***V-NOTCH*** or ***TRAPEZOIDAL*** weir.
Crest Height	Height of bottom of weir opening from invert of inlet node (feet or meters).
Discharge Coeff.	Discharge coefficient for flow through the central portion of the weir (for flow in CFS when using US units or CMS when using SI units). Typical values are: 3.33 US (1.84 SI) for sharp crested transverse weirs, 2.5 - 3.3 US (1.38 - 1.83 SI) for broad crested rectangular weirs, 2.4 - 2.8 US (1.35 - 1.55 SI) for V-notch (triangular) weirs
Flap Gate	***YES*** if the weir has a flap gate that prevents backflow, ***NO*** if it does not.
End Coeff.	Discharge coefficient for flow through the triangular ends of a ***TRAPEZOIDAL*** weir. See the recommended values for V-notch weirs listed above.
End Contractions	Number of end contractions for a ***TRANSVERSE*** or ***TRAPEZOIDAL*** weir whose length is shorter than the channel it is placed in. Either 0, 1, or 2 depending on if no ends, one end, or both ends are beveled in from the side walls.

B.11 Outlet Properties

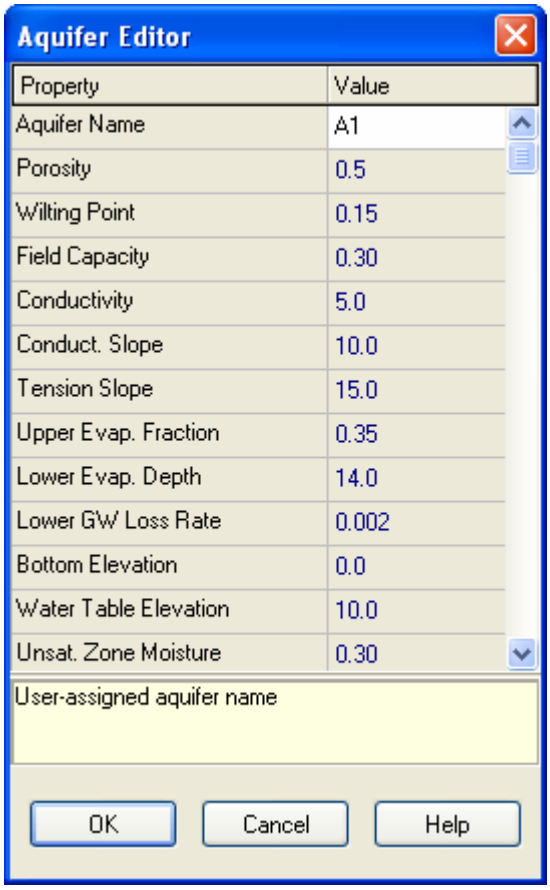
Name	User-assigned outlet name
Inlet Node	Name of node on inflow side of outlet
Outlet Node	Name of node on discharge side of outlet
Description	Click the ellipsis button (or press Enter) to edit an optional description of the outlet.
Tag	Optional label used to categorize or classify the outlet
Height	Height of outlet above inlet node invert (ft or m)
Flap Gate	***YES*** if a flap gate exists which prevents backflow through the outlet, or ***NO*** if no flap gate exists.
Rating Curve	Method of defining flow (Q) as a function of head (h) across the outlet. A ***FUNCTIONAL*** curve uses a power function ($Q = Ah^B$) to describe this relation while a ***TABULAR*** curve uses a tabulated curve of flow versus head values.
FUNCTIONAL	
- Coefficient	Coefficient (A) for the functional relationship between head and flow rate.
- Exponent	Exponent (B) used for the functional relationship between head and flow rate.
TABULAR	
- Curve Name	Name of Rating Curve containing the relationship between head and flow rate (double-click to edit the curve).

B.12 Map Label Properties

Text	Text of label.
X-Coordinate	Horizontal location of the upper-left corner of the label on the Study Area Map.
Y-Coordinate	Vertical location of the upper-left corner of the label on the Study Area Map.
Anchor Node	Name of node (or subcatchment) that anchors the label's position when the map is zoomed in (i.e., the pixel distance between the node and the label remains constant). Leave blank if anchoring is not used.
Font	Click the ellipsis button (or press Enter) to modify the font used to draw the label.

C.1 Aquifer Editor

The Aquifer Editor is invoked whenever a new aquifer object is created or an existing aquifer object is selected for editing. It contains the following data fields:



Name
User-assigned aquifer name.

Porosity
Volume of voids / total soil volume (volumetric fraction).

Wilting Point
Soil moisture content at which plants cannot survive (volumetric fraction).

Field Capacity
Soil moisture content after all free water has drained off (volumetric fraction).

Conductivity
Soil's saturated hydraulic conductivity (in/hr or mm/hr).

Conductivity Slope
Average slope of conductivity versus soil moisture content curve (in/hr or mm/hr).

Tension Slope
Average slope of soil tension versus soil moisture content curve (inches or mm).

Upper Evaporation Fraction
Fraction of total evaporation available for evapotranspiration in the upper unsaturated zone.

Lower Evaporation Depth
Maximum depth into the lower saturated zone over which evapotranspiration can occur (ft or m).

Lower Groundwater Loss Rate
Rate of percolation from saturated zone to deep groundwater (in/hr or mm/hr).

Bottom Elevation
Elevation of the bottom of the aquifer (ft or m).

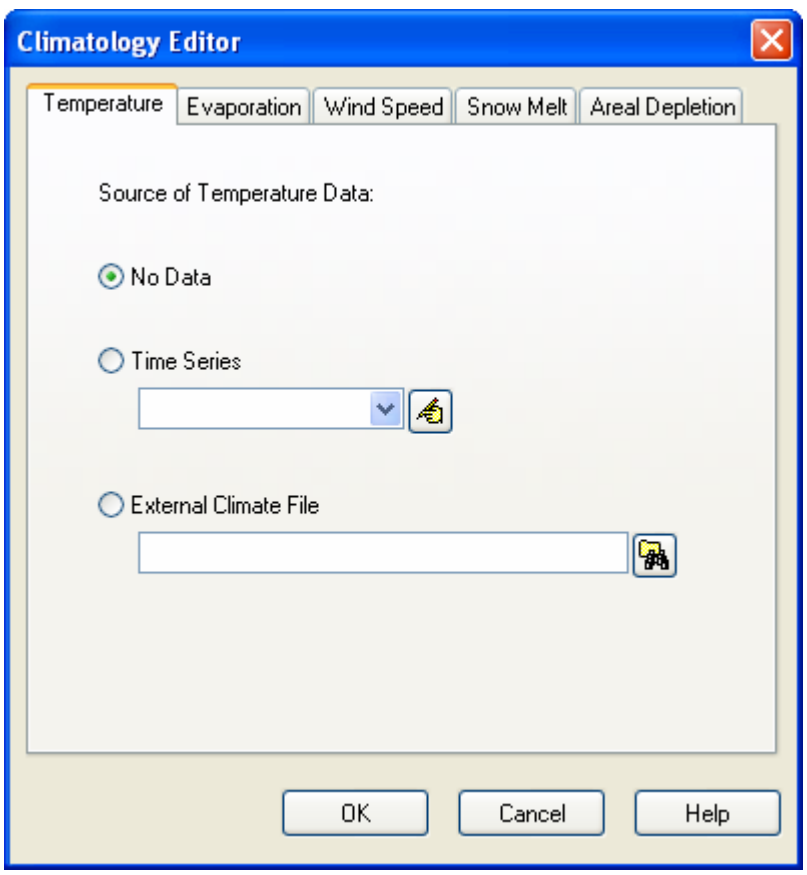
Water Table Elevation
Elevation of the water table in the aquifer at the start of the simulation (ft or m).

Unsaturated Zone Moisture
Moisture content of the unsaturated upper zone of the aquifer at the start of the simulation (volumetric fraction) (cannot exceed soil porosity).

C.2 Climatology Editor

The Climatology Editor is used to enter values for various climate-related variables required by certain SWMM simulations. The dialog is divided into five tabbed pages, where each page provides a separate editor for a specific category of climate data.

Temperature Page



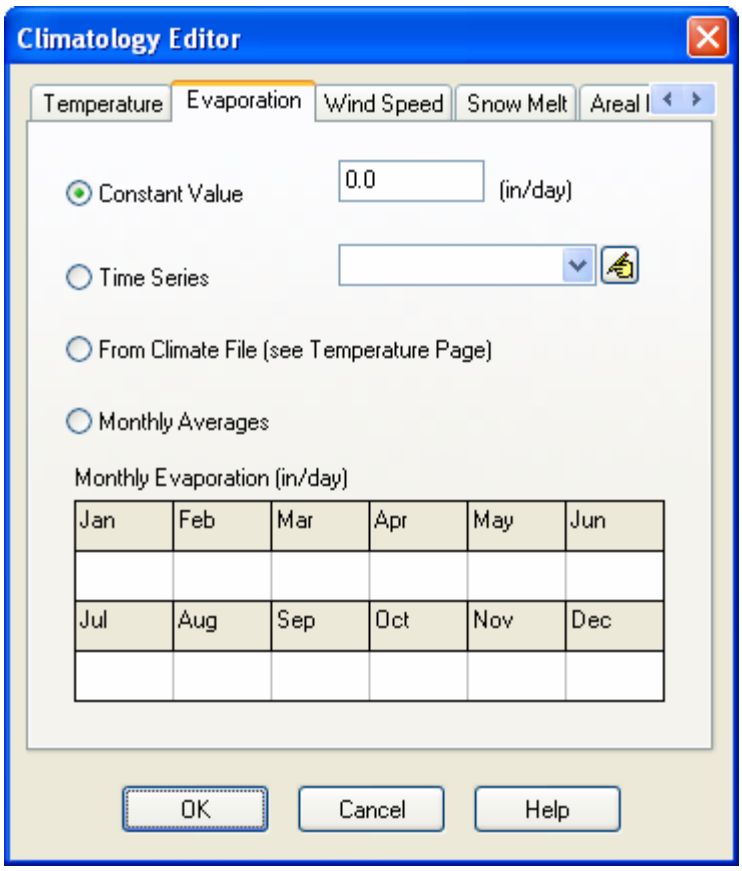
The Temperature page of the Climatology Editor dialog is used to specify the source of temperature data used for snowmelt computations. There are three choices available:

No Data: Select this choice if snowmelt is not being simulated.

Time Series: Select this choice if the variation in temperature over the simulation period will be described by one of the project's time series. Also enter (or select) the name of the time series. Click the button to make the Time Series Editor appear for the selected time series.

External Climate File: Select this choice if min/max daily temperatures will be read from an external climate file. Also enter the name of the file (or click the button to search for the file).

Evaporation Page



The Evaporation page of the Climatology Editor dialog is used to supply evaporation rates, in inches/day (or mm/day), for a study area. There are four choices for specifying these rates:

Constant: Use this choice if evaporation remains constant over time. Enter the value in the edit box provided.

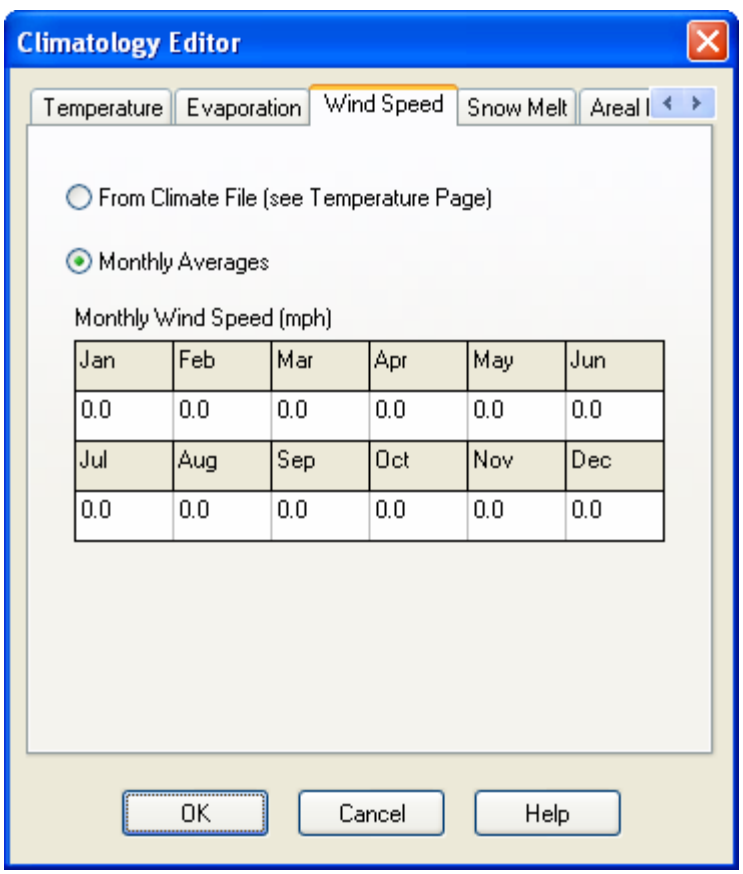
Time Series: Select this choice if evaporation rates will be specified in a time series. Enter or select the name of the time series

in the dropdown combo box provided. Click the button to bring up the Time Series editor for the selected series. Note that for each date specified in the time series, the evaporation rate remains constant at the value supplied for that date until the next date in the series is reached (i.e., interpolation is not used on the series).

From Climate File: This choice indicates that evaporation rates will be read from the same climate file that was specified for temperature. Enter values for monthly pan coefficients in the data grid provided.

Monthly Averages: Use this choice to supply an average rate for each month of the year. Enter the value for each month in the data grid provided. Note that rates remain constant within each month.

Wind Speed Page

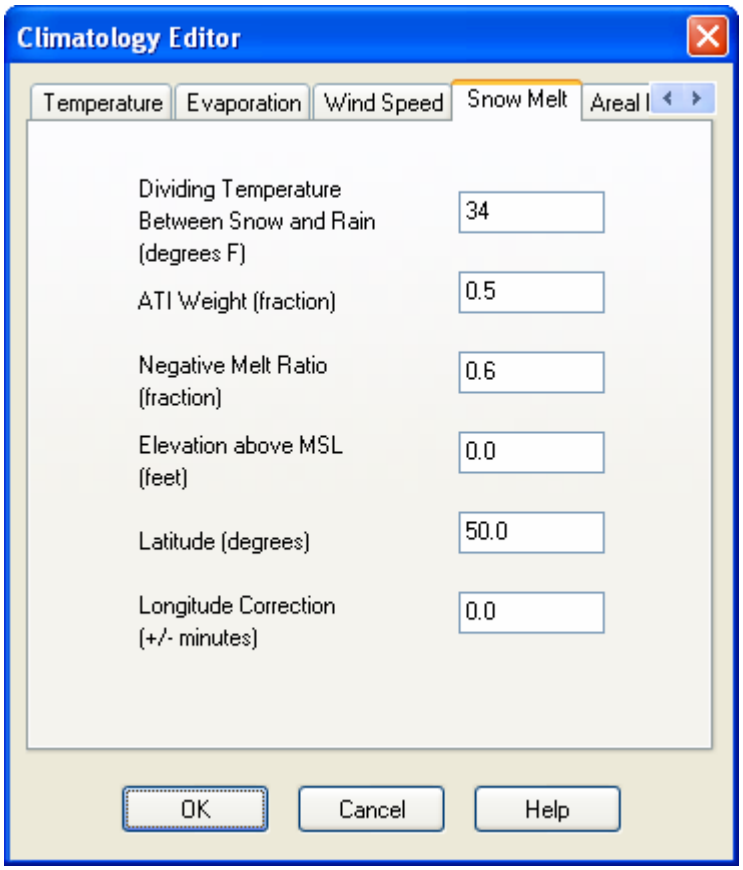


The Wind Speed page of the Climatology Editor dialog is used to provide average monthly wind speeds. These are used when computing snowmelt rates under rainfall conditions. Melt rates increase with increasing wind speed. Units of wind speed are miles/hour for US units and km/hour for metric units. There are two choices for specifying wind speeds:

From Climate File: Wind speeds will be read from the same climate file that was specified for temperature.

Monthly Averages: Wind speed is specified as an average value that remains constant in each month of the year. Enter a value for each month in the data grid provided. The default values are all zero.

Snowmelt Page



The Snowmelt page of the Climatology Editor dialog is used to supply values for the following parameters related to snow melt calculations:

<u>Dividing Temperature Between Snow and Rain</u>
Enter the temperature below which precipitation falls as snow instead of rain. Use degrees F for US units or degrees C for metric units.

<u>ATI (Antecedent Temperature Index) Weight</u>
This parameter reflects the degree to which heat transfer within a snow pack during non-melt periods is affected by prior air temperatures. Smaller values reflect a thicker surface layer of snow which results in reduced rates of heat transfer. Values must be between 0 and 1, and the default is 0.5.

Negative Melt Ratio
This is the ratio of the heat transfer coefficient of a snow pack during non-melt conditions to the coefficient during melt conditions. It must be a number between 0 and 1. The default value is 0.6.

Elevation Above MSL
Enter the average elevation above mean sea level for the study area, in feet or meters. This value is used to provide a more accurate estimate of atmospheric pressure. The default is 0.0, which results in a pressure of 29.9 inches Hg. The effect of wind on snow melt rates during rainfall periods is greater at higher pressures, which occur at lower elevations.

Latitude
Enter the latitude of the study area in degrees North. This number is used when computing the hours of sunrise and sunset, which in turn are used to extend min/max daily temperatures into continuous values. The default is 50 degrees North.

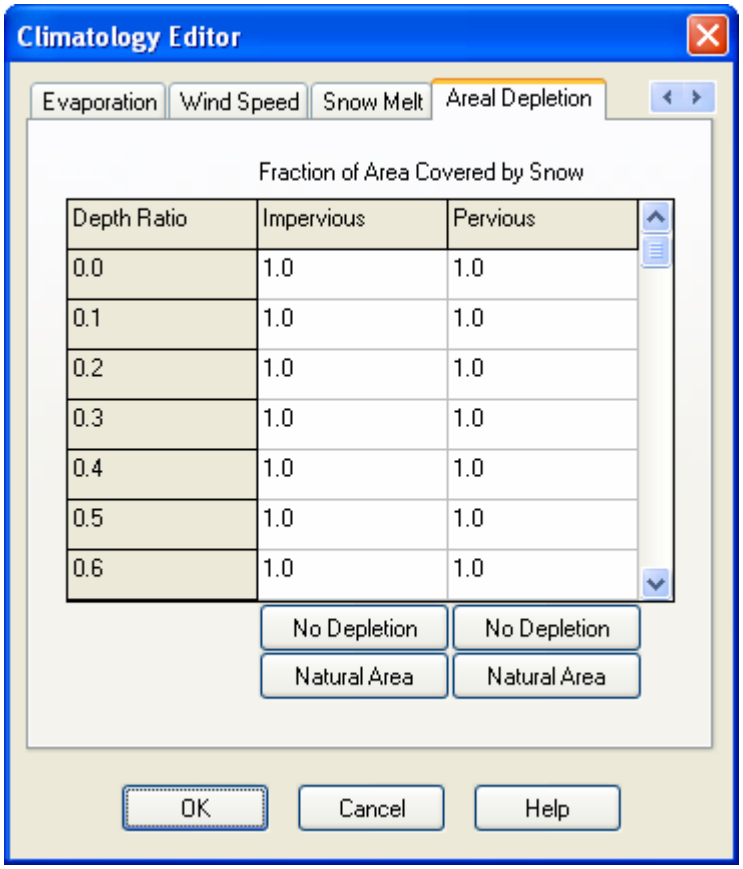
Longitude Correction
This is a correction, in minutes of time, between true solar time and the standard clock time. It depends on a location's longitude (θ) and the standard meridian of its time zone (SM) through the expression $4(\theta\text{-SM})$. This correction is used to adjust the hours of sunrise and sunset when extending daily min/max temperatures into continuous values. The default value is 0.

Areal Depletion Page

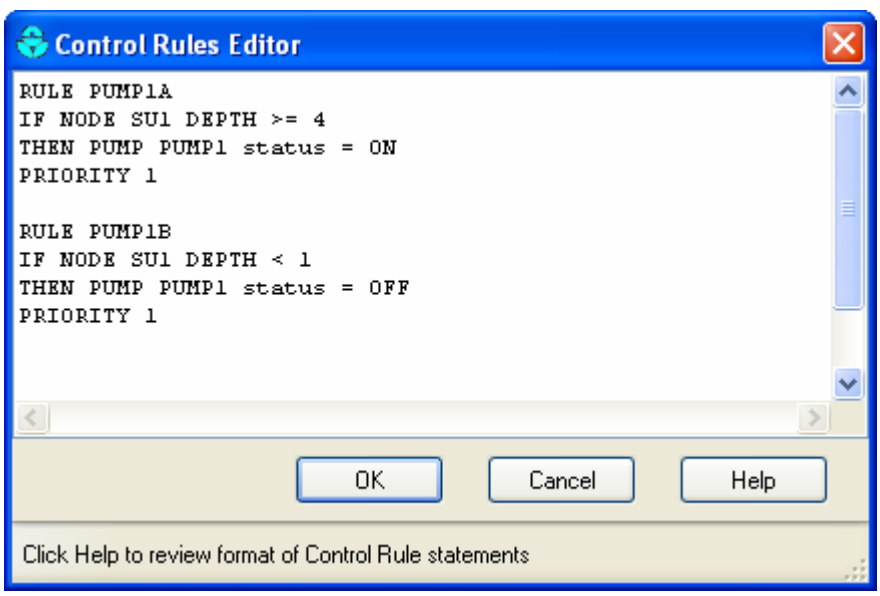
The Areal Depletion page of the Climatology Editor Dialog is used to specify points on the Areal Depletion Curves for both impervious and pervious surfaces within a project's study area. These curves define the relation between the area that remains snow covered and snow pack depth. Each curve is defined by 10 equal increments of relative depth ratio between 0 and 0.9. (Relative depth ratio is the ratio of an area's current snow depth to the depth at which there is 100% areal coverage).

Enter values in the data grid provided for the fraction of each area that remains snow covered at each specified relative depth ratio. Valid numbers must be between 0 and 1, and be increasing with increasing depth ratio.

Clicking the **Natural Area** button fills the grid with values that are typical of natural areas. Clicking the **No Depletion** button will fill the grid with all 1's, indicating that no areal depletion occurs. This is the default for new projects.



C.3 Control Rules Editor



The Control Rules Editor is invoked whenever a new control rule is created or an existing rule is selected for editing. The editor contains a memo field where the entire collection of control rules is displayed and can be edited.

Control Rule Format

Each control rule is a series of statements of the form:

```
RULE  ruleID

IF    condition_1
AND   condition_2
OR    condition_3
AND   condition_4
Etc.

THEN  action_1
AND   action_2
Etc.

ELSE  action_3
AND   action_4
Etc.

PRIORITY value
```

where keywords are shown in boldface and `ruleID` is an ID label assigned to the rule, `condition_n` is a Condition Clause, `action_n` is an Action Clause, and `value` is a priority value (e.g., a number from 1 to 5). The formats used for Condition and Action clauses are discussed below.

Only the **RULE**, **IF** and **THEN** portions of a rule are required; the **ELSE** and **PRIORITY** portions are optional.

Blank lines between clauses are permitted and any text to the right of a semicolon is considered a comment.

When mixing **AND** and **OR** clauses, the **OR** operator has higher precedence than **AND**, i.e.,
`IF A or B and C`
is equivalent to
`IF (A or B) and C.`
If the interpretation was meant to be
`IF A or (B and C)`
then this can be expressed using two rules as in
```
IF A THEN ...
IF B and C THEN ...
```

The **PRIORITY** value is used to determine which rule applies when two or more rules require that conflicting actions be taken on a link. A rule without a priority value always

has a lower priority than one with a value. For two rules with the same priority value, the rule that appears first is given the higher priority.

Condition Clauses

A Condition Clause of a control rule has the following format:

```
object id attribute relation value
```

where

`object`	=	a category of object
`id`	=	the object's ID label
`attribute`	=	an attribute or property of the object
`relation`	=	a relational operator (=, <>, <, <=, >, >=)
`value`	=	an attribute value

Some examples of condition clauses are:

```
NODE  N23  DEPTH  >  10
PUMP  P45  STATUS =  OFF
SIMULATION CLOCKTIME = 22:45:00
```

The objects and attributes that can appear in a condition clause are as follows:

Object	**Attributes**	**Value**

`NODE`	`DEPTH`
	`HEAD`
	`INFLOW`
		numerical value
		numerical value
		numerical value

`LINK`	`FLOW` `DEPTH`	numerical value numerical value
`PUMP`	`STATUS` `FLOW`	`ON` or `OFF` numerical value
`ORIFICE` `WEIR`	`SETTING`	fraction open

`SIMULATION`	`TIME`
	`DATE`
	`CLOCKTIME`
		elapsed time in decimal hours or hr:min:sec
		month/day/year
		time of day in hr:min:sec

Action Clauses

An Action Clause of a control rule can have one of the following formats:

```
PUMP      id  STATUS   =  ON/OFF
ORIFICE   id  SETTING  =  value
WEIR      id  SETTING  =  value
```

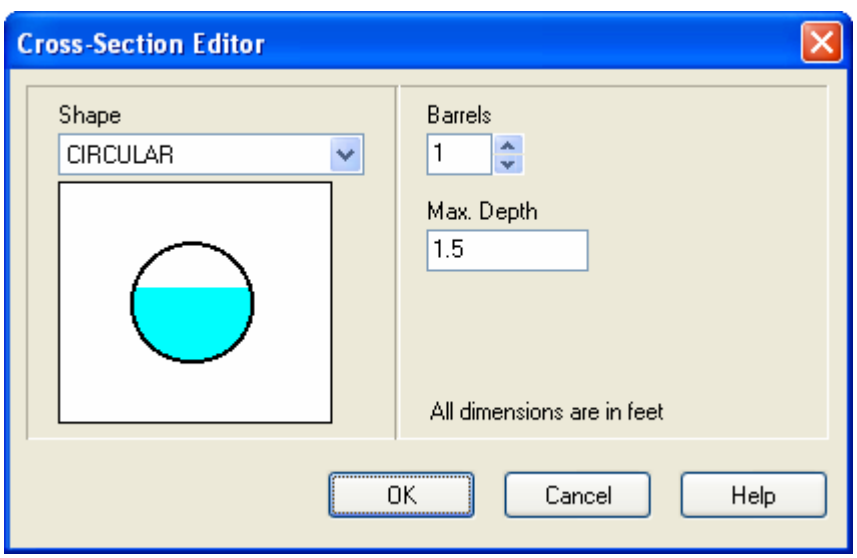
where `SETTING` refers to the fractional amount that an orifice is fully open or to the fractional amount of the original height between the crest and the top of a weir that remains (i.e., weir control is accomplished by moving the crest height up and down).

Some examples of action clauses are:

```
PUMP P67 STATUS = OFF
ORIFICE O212 SETTING = 0.5
```

C.4 Cross-Section Editor

The Cross-Section Editor dialog is used to specify the shape and dimensions of a conduit's cross-section.

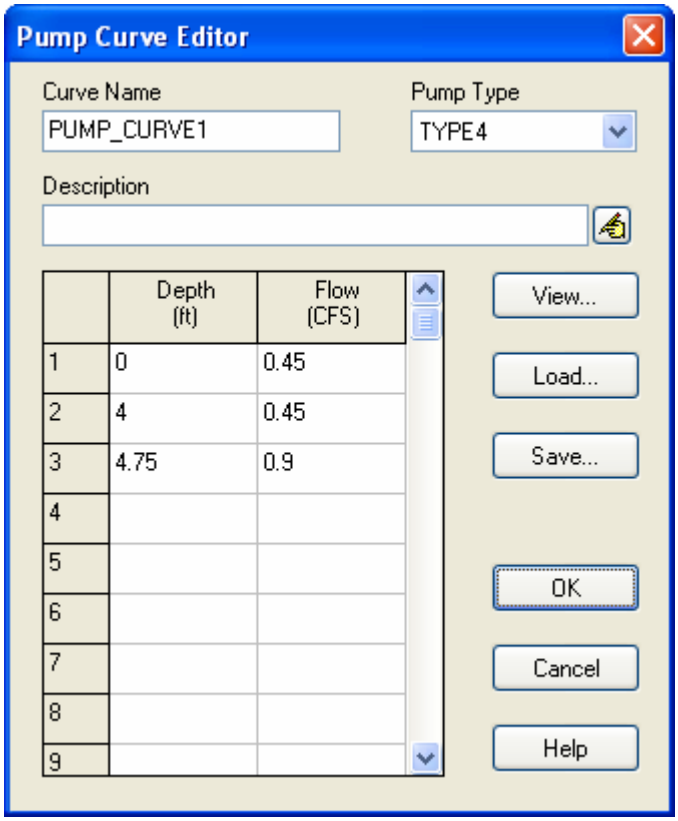


When a shape is selected from the dropdown combo box an appropriate set of edit fields appears for describing the dimensions of that shape. Length dimensions are in units of feet for US units and meters for SI units. Slope values represent ratios of horizontal to vertical distance. The Barrels field specifies how many identical parallel conduits exist between its end nodes.

If an Irregular shaped section is chosen, a drop-down edit box will appear where you can enter or select the name of a Transect object that describes the cross-section's geometry. Clicking the Edit button next to the edit box will bring up the Transect Editor which allows you to edit the transect's data.

C.5 Curve Editor

The Curve Editor dialog is invoked whenever a new curve object is created or an existing curve object is selected for editing. The editor adapts itself to the category of curve being edited (Storage, Tidal, Diversion, Pump, or Rating). To use the Curve Editor:



- Enter values for the following data entry fields:

  Name — Name of the curve.

  Type — (Pump Curves Only). Choice of pump curve type as described in Section 3.2 - Pumps.

  Description — Optional comment or description of what the curve represents. Click the button to launch a multi-line comment editor if more than one line is needed.

  Data Grid — The curve's X,Y data.

- Click the **View** button to see a graphical plot of the curve drawn in a separate window.
- If additional rows are needed in the Data Grid, simply press the **Enter** key when in the last row.
- Right-clicking over the Data Grid will make a popup Edit menu appear. It contains commands to cut, copy, insert, and paste selected cells in the grid as well as options to insert or delete a row.

You can also click the **Load** button to load in a curve that was previously saved to file or click the **Save** button to save the current curve's data to a file.

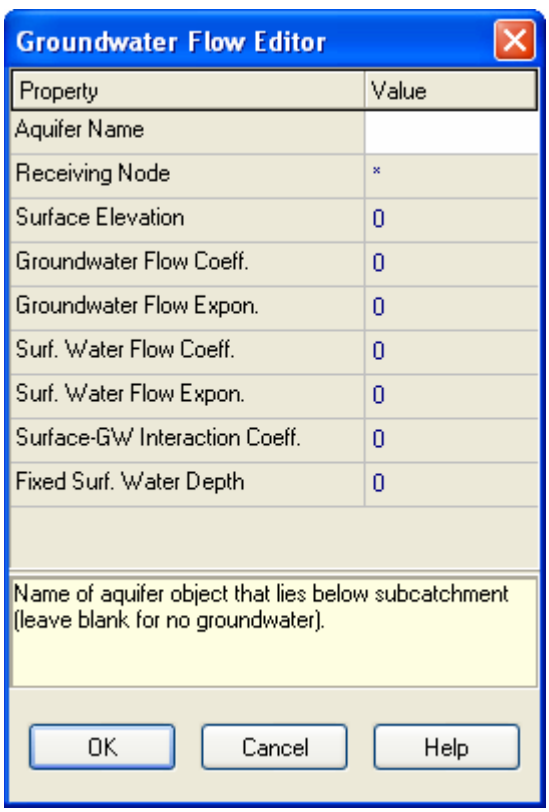
C.6 Groundwater Flow Editor

The Groundwater Flow Editor dialog is invoked when the Groundwater property of a subcatchment is being edited. It is used to link a subcatchment to both an aquifer and to a node of the drainage system that exchanges groundwater with the aquifer. It also specifies coefficients that determine the rate of groundwater flow between the aquifer and the node. These coefficients (A1, A2, B1, B2, and A3) appear in the following equation that computes groundwater flow as a function of groundwater and surface water heads:

$$Q_{gw} = A1\left(H_{gw} - E\right)^{B1} - A2\left(H_{sw} - E\right)^{B2} + A3H_{gw}H_{sw}$$

where:

Q_{gw} = groundwater flow (cfs per acre or cms per hectare)
H_{gw} = elevation of groundwater table (ft or m)
H_{sw} = elevation of surface water at receiving node (ft or m)
E = elevation of node invert (ft or m).



The properties listed in the editor are as follows:

Aquifer Name
Name of aquifer object that supplies groundwater. Leave this field blank if you want the subcatchment not to generate any groundwater flow.

Receiving Node
Name of node that receives groundwater from the aquifer.

Surface Elevation
Elevation of ground surface for the subcatchment that lies above the aquifer in feet or meters.

Groundwater Flow Coefficient
Value of A1 in the groundwater flow formula.

Groundwater Flow Exponent
Value of B1 in the groundwater flow formula.

Surface Water Flow Coefficient
Value of A2 in the groundwater flow formula.

Surface Water Flow Exponent
Value of B2 in the groundwater flow formula.

Surface-GW Interaction Coefficient
Value of A3 in the groundwater flow formula.

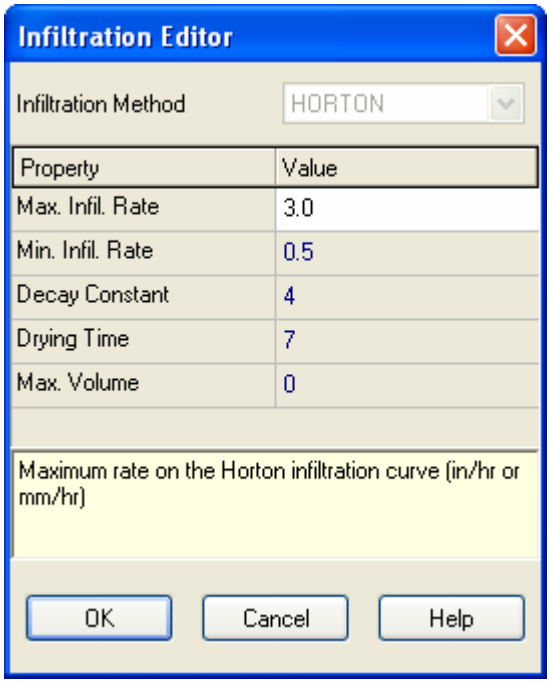
Fixed Surface Water Depth
Fixed depth of surface water at the receiving node (feet or meters) (set to zero if surface water depth will vary as computed by flow routing).

The values of the flow coefficients must be in units that are consistent with the groundwater flow units of cfs/acre for US units or cms/ha for metric units.

If groundwater flow is simply proportional to the difference in groundwater and surface water heads, then set the Groundwater and Surface Water Flow Exponents (B1 and B2) to 1.0, set the Groundwater Flow Coefficient (A1) to the proportionality factor, set the Surface Water Flow Coefficient (A2) to the same value as A1, and set the Interaction Coefficient (A3) to zero.

C.7 Infiltration Editor

The **Infiltration Editor** dialog is used to specify values for the parameters that describe the rate at which rainfall infiltrates into the upper soil zone in a subcatchment's pervious area. It is invoked when editing the Infiltration property of a subcatchment. The infiltration parameters depend on which infiltration model was selected for the project: Horton, Green-Ampt, or Curve Number. The choice of infiltration model can be made either by editing the project's Simulation Options (see Section 8.1) or by changing the project's Default Properties (see Section 5.4).



Horton Infiltration Parameters

The following data fields appear in the Infiltration Editor for Horton infiltration:

<u>Max. Infil. Rate</u>
Maximum infiltration rate on the Horton curve (in/hr or mm/hr). Representative values are as follows:

1. DRY soils (with little or no vegetation):
   - Sandy soils: 5 in/hr
   - Loam soils: 3 in/hr
   - Clay soils: 1 in/hr

2. DRY soils (with dense vegetation):
   - Multiply values in A. by 2

3. MOIST soils:
   - Soils which have drained but not dried out (i.e., field capacity):
     Divide values from A and B by 3.
   - Soils close to saturation:
     Choose value close to min. infiltration rate.
   - Soils which have partially dried out:
     Divide values from A and B by 1.5 - 2.5.

<u>Min. Infil. Rate</u>
Minimum infiltration rate on the Horton curve (in/hr or mm/hr). Equivalent to the soil's saturated hydraulic conductivity. See the Soil Characteristics Table in Section A.2 for typical values.

Decay Const.
Infiltration rate decay constant for the Horton curve (1/hours). Typical values range between 2 and 7.

Drying Time
Time in days for a fully saturated soil to dry completely. Typical values range from 2 to 14 days.

Max. Infil. Vol.
Maximum infiltration volume possible (inches or mm, 0 if not applicable). Can be estimated as the difference between a soil's porosity and its wilting point times the depth of the infiltration zone.

Green-Ampt Infiltration Parameters

The following data fields appear in the Infiltration Editor for Green-Ampt infiltration:

Suction Head
Average value of soil capillary suction along the wetting front (inches or mm).

Conductivity
Soil saturated hydraulic conductivity (in/hr or mm/hr).

Initial Deficit
Difference between soil porosity and initial moisture content (a fraction). For a completely drained soil, it is the difference between the soil's porosity and its field capacity.

Typical values for all of these parameters can be found in the Soil Characteristics Table in Section A.2.

Curve Number Infiltration Parameters

The following data fields appear in the Infiltration Editor for Curve Number infiltration:

Curve Number
This is the SCS curve number which is tabulated in the publication *SCS Urban Hydrology for Small Watersheds*, 2nd Ed., (TR-55), June 1986. Consult the Curve Number Table (Section A.4) for a listing of values by soil group, and the accompanying Soil Group Table (Section A.3) for the definitions of the various groups.

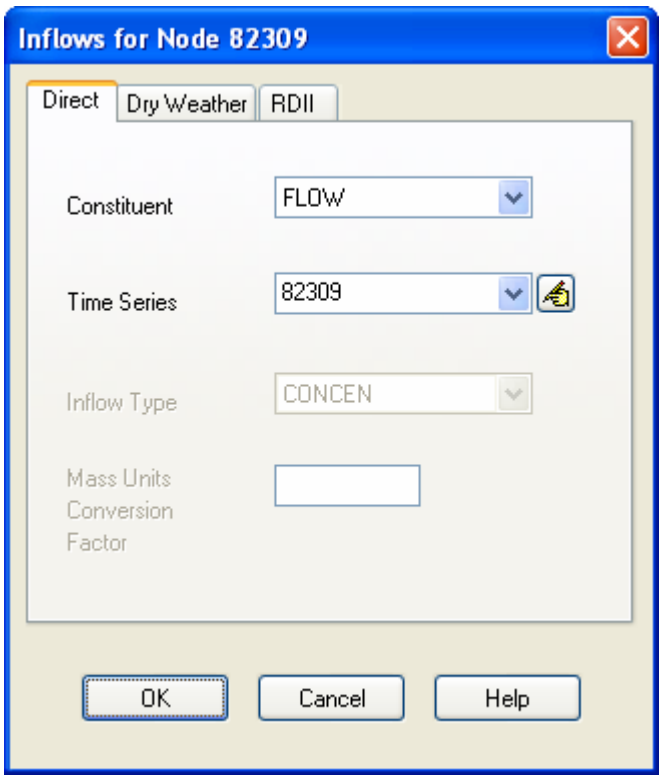
Conductivity
The soil's saturated hydraulic conductivity (in/hr or mm/hr). Typical ranges are shown in both the Soil Group Table (Section A.3) and in the Soil Characteristics Table (Section A.2).

Drying Time
The number of days it takes a fully saturated soil to dry. Typical values range between 2 and 14 days.

C.8 Inflows Editor

The Inflows Editor dialog is used to assign Direct, Dry Weather, and RDII inflow into a node of the drainage system. It is invoked whenever the Inflows property of a Node object is selected in the Property Editor. The dialog consists of three tabbed pages that provide a special editor for each type of inflow.

Direct Inflows Page



The Direct page on the Inflows Editor dialog is used to specify time series of direct external inflow and pollutant inflows entering a node of the drainage system. The dialog consists of the following input fields:

<u>Constituent</u>
Selects the constituent (FLOW or one of the project's specified pollutants) whose direct inflow will be described.

<u>Time Series</u>
Specifies the name of the time series that contains inflow data for the selected constituent. If left blank then no direct inflow will occur for the selected constituent at the node in question. You can click the button to bring up the Time Series Editor dialog for the selected time series.

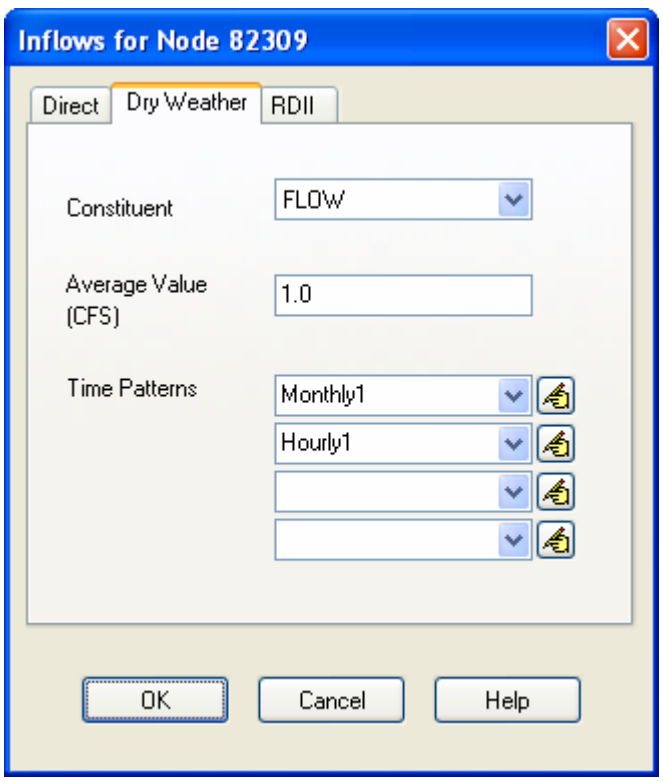
<u>Inflow Type</u>
For pollutants, selects the type of inflow data contained in the time series as being either concentrations or mass flows.

Conversion Factor
A numerical factor used to convert the units of pollutant mass flow rate in the time series data into concentration mass units per second. For example, if the time series data were in pounds per day and the pollutant concentration defined in the project was mg/L, then the conversion factor value would be (453,590 mg/lb) / (86400 sec/day) = 5.25 (mg/sec) per (lb/day).

More than one constituent can be edited while the dialog is active by simply selecting another choice for the Constituent property. However, if the Cancel button is clicked then any changes made to all constituents will be ignored.

If a pollutant is assigned a direct inflow in terms of concentration, then one must also assign a direct inflow to flow, otherwise no pollutant inflow will occur. If pollutant inflow is defined in terms of mass, then a flow inflow time series is not required.

Dry Weather Inflows Page



The Dry Weather page of the Inflows Editor dialog is used to specify a continuous source of dry weather flow entering a node of the drainage system. The dialog consists of the following input fields:

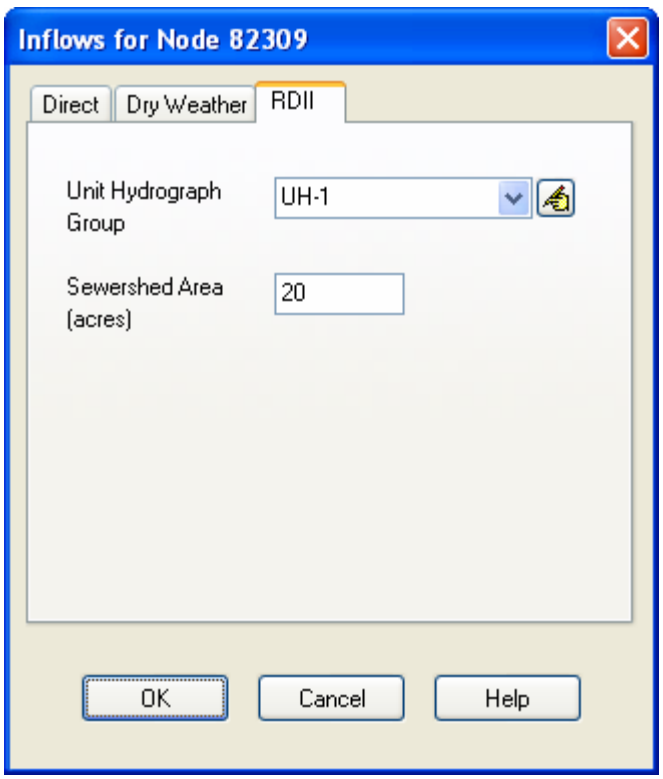
Constituent
Selects the constituent (FLOW or one of the project's specified pollutants) whose dry weather inflow will be specified.

Average Value
Specifies the average (or baseline) value of the dry weather inflow of the constituent in the relevant units (flow units for flow, concentration units for pollutants). Leave blank if there is no dry weather flow for the selected constituent.

Time Patterns
Specifies the names of the time patterns to be used to allow the dry weather flow to vary in a periodic fashion by month of the year, by day of the week, and by time of day (for both weekdays and weekends). One can either type in a name or select a previously defined pattern from the dropdown list of each combo box. Up to four different types of patterns can be assigned. You can click the button next to each Time Pattern field to edit the respective pattern.

More than one constituent can be edited while the dialog is active by simply selecting another choice for the Constituent property. However, if the Cancel button is clicked then any changes made to all constituents will be ignored.

RDII Inflow Page



The RDII page of the Inflows Editor dialog is used to specify RDII (rainfall-dependent infiltration/inflow) for the node in question. The editor contains the following two input fields:

Unit Hydrograph Group
Enter (or select from the dropdown list) the name of the Unit Hydrograph group that applies to the node in question. The unit hydrographs in the group are used in

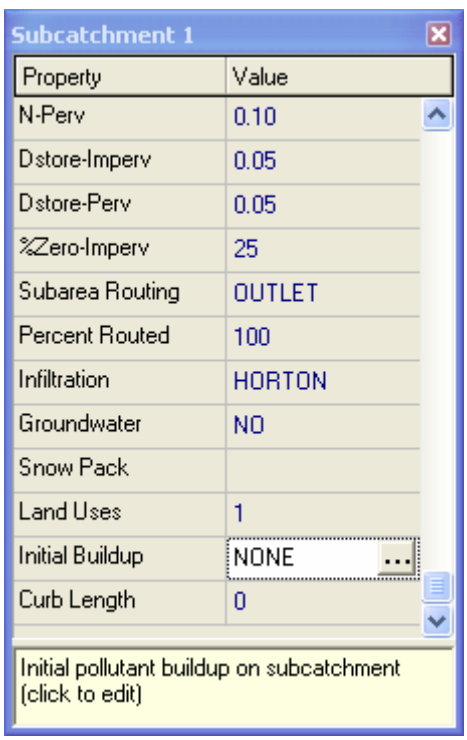
combination with the group's assigned rain gage to develop a time series of RDII inflows per unit area over the period of the simulation. Leave this field blank to indicate that the node receives no RDII inflow. Clicking the button will launch the Unit Hydrograph Editor for the UH group specified.

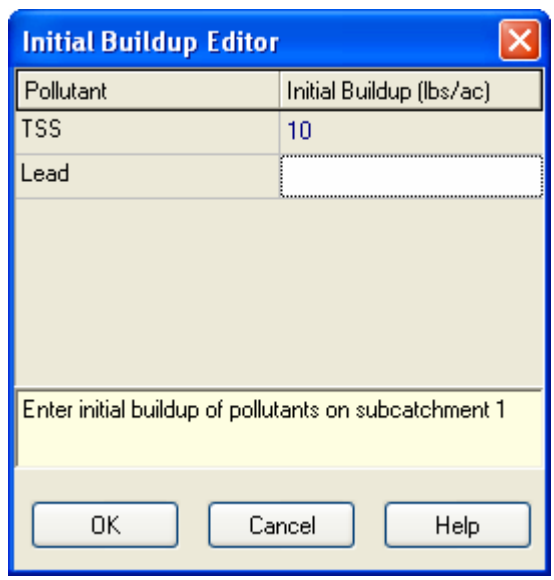
Sewershed Area

Enter the area (in acres or hectares) of the sewershed that contributes RDII to the node in question. Note this area will typically be only a small, localized portion of the subcatchment area that contributes surface runoff to the node.

C.9 Initial Buildup Editor

The Initial Buildup Editor is invoked from the Property Editor when editing the Initial Buildup property of a subcatchment. It specifies the amount of pollutant buildup existing over the subcatchment at the start of the simulation. The editor consists of a data entry grid with two columns. The first column lists the name of each pollutant in the project and the second column contains edit boxes for entering the initial buildup values. If no buildup value is supplied for a pollutant, it is assumed to be 0. The units for buildup are either pounds per acre when US units are in use or kilograms per hectare when SI metric units are in use.





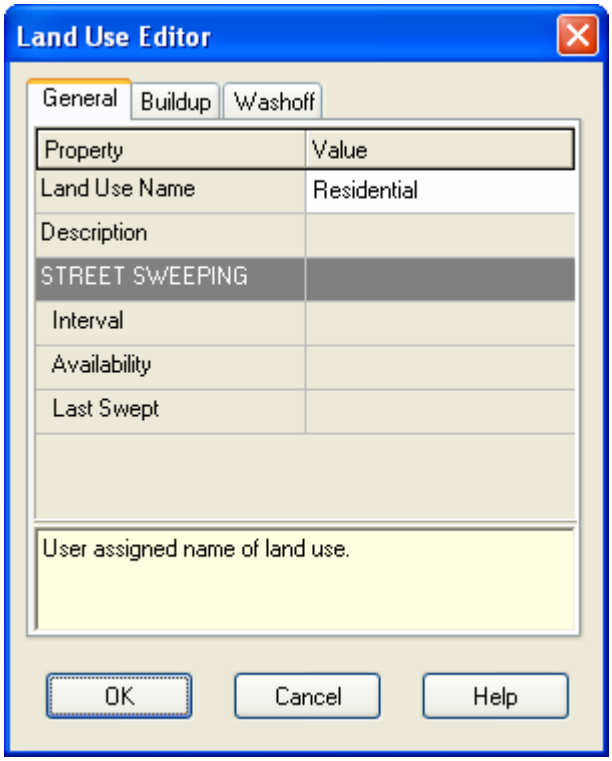
If a non-zero value is specified for the initial buildup of a pollutant, it will override any initial buildup computed from the Antecedent Dry Days parameter specified on the Dates page of the Simulation Options dialog.

C.10 Land Use Editor

The Land Use Editor dialog is used to define a category of land use for the study area and to define its pollutant buildup and washoff characteristics. The dialog contains three tabbed pages of land use properties:

- General Page (provides land use name and street sweeping parameters)
- Buildup Page (defines rate at which pollutant buildup occurs)
- Washoff Page (defines rate at which pollutant washoff occurs)

General Page



The General page of the Land Use Editor dialog describes the following properties of a particular land use category:

<u>Land Use Name</u>
The name assigned to the land use.

<u>Description</u>
An optional comment or description of the land use (click the ellipsis button or press Enter to edit).

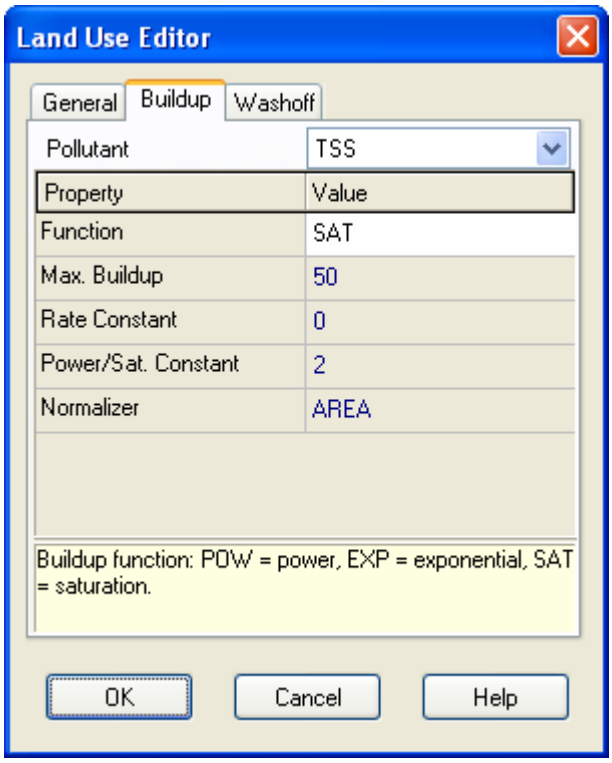
<u>Street Sweeping Interval</u>
Days between street sweeping within the land use.

Street Sweeping Availability
Fraction of the buildup of all pollutants that is available for removal by sweeping.

Last Swept
Number of days since last swept at the start of the simulation.

If street sweeping does not apply to the land use, then the last three properties can be left blank.

Buildup Page



The Buildup page of the Land Use Editor dialog describes the properties associated with pollutant buildup over the land during dry weather periods. These consist of:

Pollutant
Select the pollutant whose buildup properties are being edited.

Function
The type of buildup function to use for the pollutant. The choices are **NONE** for no buildup, **POW** for power function buildup, **EXP** for exponential function buildup and **SAT** for saturation function buildup. See the discussion of Pollutant Buildup in Section 3.3.9 for explanations of these different functions. Select **NONE** if no buildup occurs.

Max. Buildup
The maximum buildup that can occur, expressed as lbs (or kg) of the pollutant per unit of the normalizer variable (see below). This is the same as the C1 coefficient used in the buildup formulas discussed in Section 3.3.9.

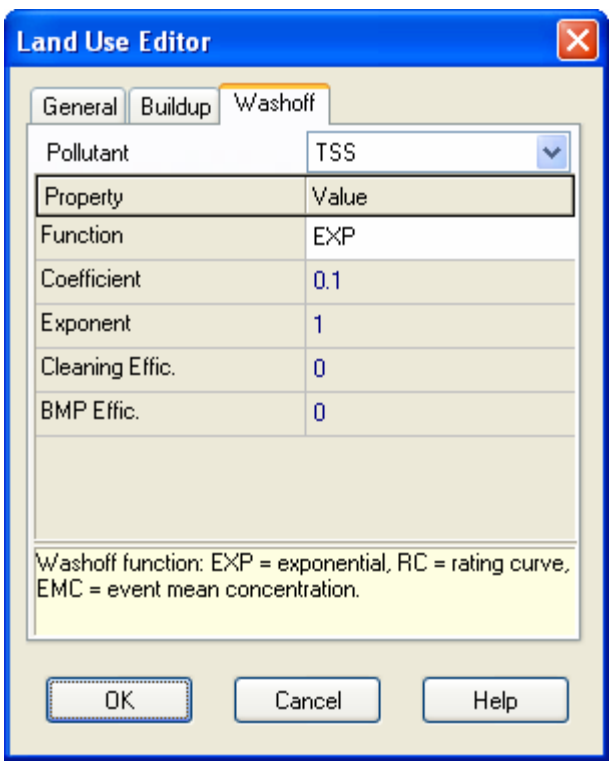
Rate Constant
The time constant that governs the rate of pollutant buildup. This is the C2 coefficient in the Power and Exponential buildup formulas discussed in Section 3.3.9. For Power buildup its units are mass / days raised to a power, while for Exponential buildup its units are 1/days.

Power/Sat. Constant
The exponent C3 used in the Power buildup formula, or the half-saturation constant C2 used in the Saturation buildup formula discussed in Section 3.3.9. For the latter case, its units are days.

Normalizer
The variable to which buildup is normalized on a per unit basis. The choices are either land area (in acres or hectares) or curb length. Any units of measure can be used for curb length, as long as they remain the same for all subcatchments in the project.

When there are multiple pollutants, the user must select each pollutant separately from the Pollutant dropdown list and specify its pertinent buildup properties.

Washoff Page



The Washoff page of the Land Use Editor dialog describes the properties associated with pollutant washoff over the land use during wet weather events. These consist of:

Pollutant
The name of the pollutant whose washoff properties are being edited.

Function
The choice of washoff function to use for the pollutant. The choices are:

- *NONE* no washoff
- *EXP* exponential washoff
- *RC* rating curve washoff
- *EMC* event-mean concentration washoff.

The formula for each of these functions is discussed in Section 3.3.9 under the Pollutant Washoff topic.

Coefficient
This is the value of C1 in the exponential and rating curve formulas, or the event-mean concentration.

Exponent
The exponent used in the exponential and rating curve washoff formulas.

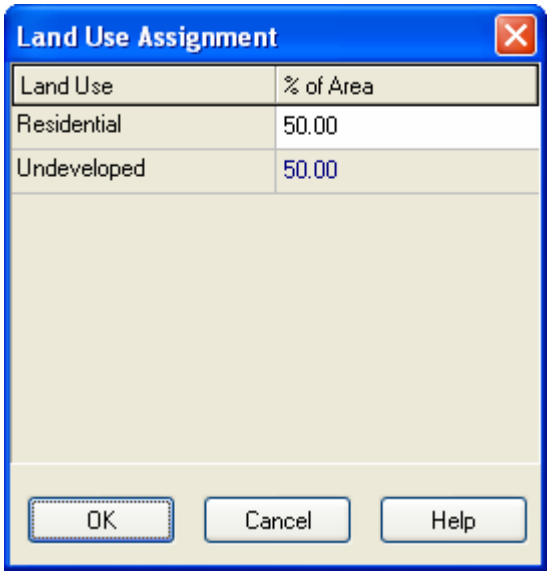
Cleaning Efficiency
The street cleaning removal efficiency (percent) for the pollutant. It represents the fraction of the amount that is available for removal on the land use as a whole (set on the General page of the editor) which is actually removed.

BMP Efficiency
Removal efficiency (percent) associated with any Best Management Practice that might have been implemented. The washoff load computed at each time step is simply reduced by this amount.

As with the Buildup page, each pollutant must be selected in turn from the Pollutant dropdown list and have its pertinent washoff properties defined.

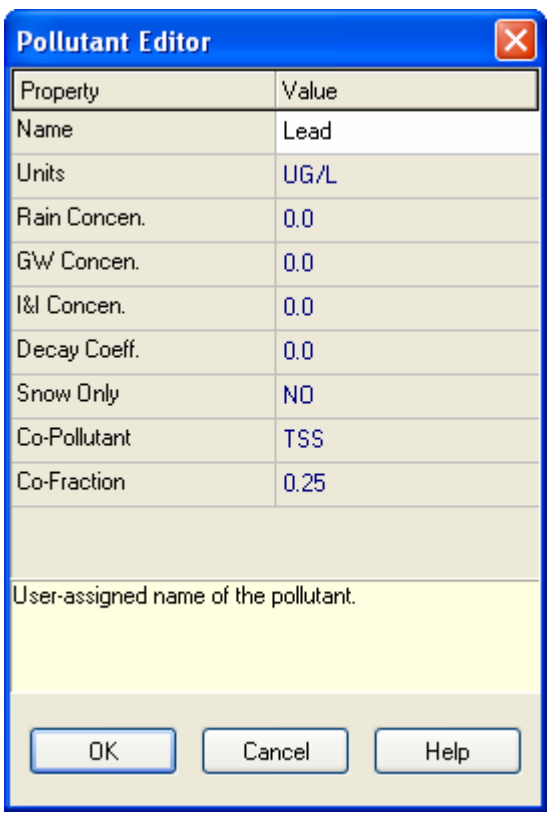
C.11 Land Use Assignment Editor

The Land Use Assignment editor is invoked from the Property Editor when editing the Land Uses property of a subcatchment. Its purpose is to assign land uses to the subcatchment for water quality simulations. The percent of land area in the subcatchment covered by each land use is entered next to its respective land use category. If the land use is not present its field can be left blank. The percentages entered do not necessarily have to add up to 100.



C.12 Pollutant Editor

The Pollutant Editor is invoked when a new pollutant object is created or an existing pollutant is selected for editing. It contains the following fields:



Name
The name assigned to the pollutant.

Units
The concentration units (**mg/L**, **ug/L**, or **#/L** (counts/L)) in which the pollutant concentration is expressed.

Rain Concentration
Concentration of the pollutant in rain water (concentration units).

GW Concentration
Concentration of the pollutant in ground water (concentration units).

I&I Concentration
Concentration of the pollutant in any Infiltration/Inflow (concentration units)

Decay Coefficient
First-order decay coefficient of the pollutant (1/days).

Snow Only
YES if pollutant buildup occurs only when snowfall occurs, **NO** otherwise (default is **NO**).

Co-Pollutant
Name of another pollutant whose runoff concentration contributes to the runoff concentration of the current pollutant.

Co-Fraction
Fraction of the co-pollutant's runoff concentration that contributes to the runoff concentration of the current pollutant.

An example of a co-pollutant relationship would be where the runoff concentration of a particular heavy metal is some fixed fraction of the runoff concentration of suspended solids. In this case suspended solids would be declared as the co-pollutant for the heavy metal.

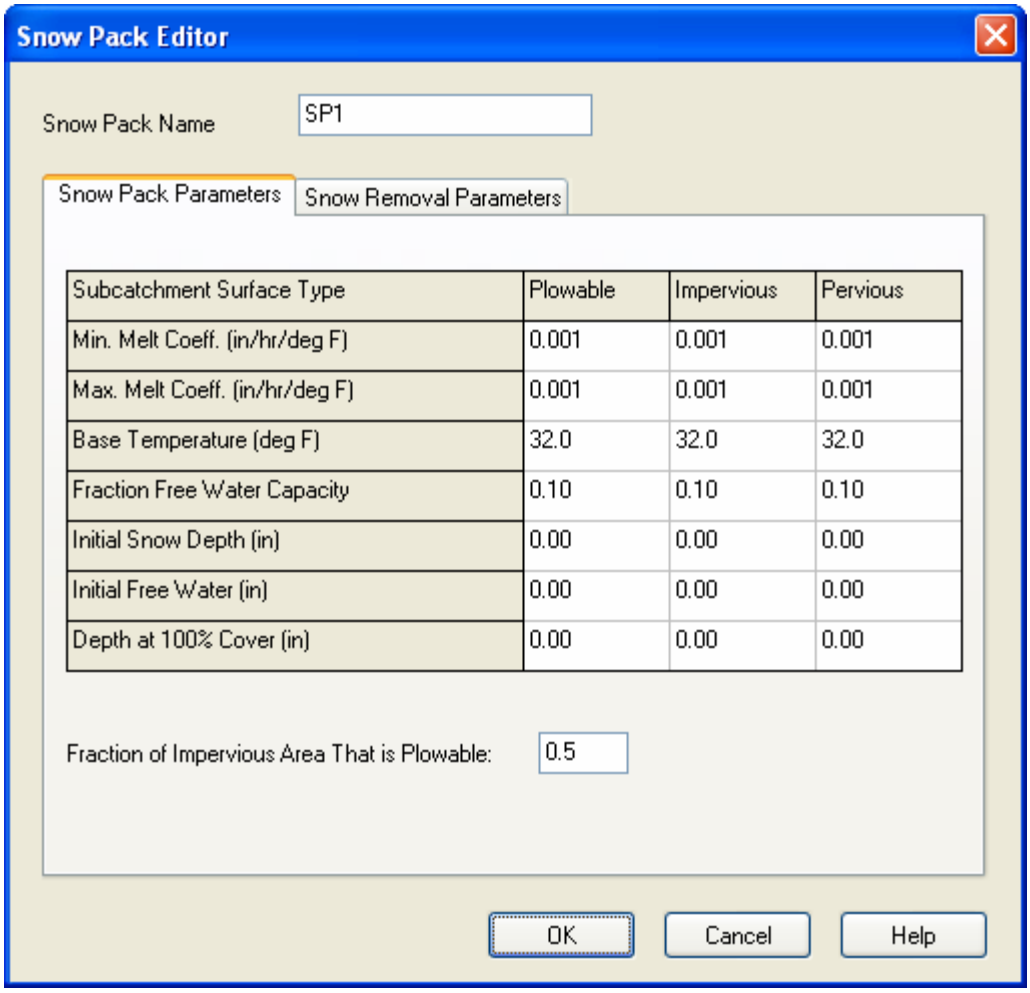
C13. Snow Pack Editor

The Snow Pack Editor is invoked when a new snow pack object is created or an existing snow pack is selected for editing. The editor contains a data entry field for the snow pack's name and two tabbed pages, one for snow pack parameters and one for snow removal parameters.

Snow Pack Parameters Page

The Parameters page of the Snow Pack Editor dialog provides snow melt parameters and initial conditions for snow that accumulates over three different types of areas: the impervious area that is plowable (i.e., subject to snow removal), the remaining

impervious area, and the entire pervious area. The page contains a data entry grid which has a column for each type of area and a row for each of the following parameters:



Min. Melt Coefficient
The degree-day snow melt coefficient that occurs on December 21. Units are either in/hr-deg F or mm/hr-deg C.

Max. Melt Coefficient
The degree-day snow melt coefficient that occurs on June 21. Units are either in/hr-deg F or mm/hr-deg C. For a short term simulation of less than a week or so it is acceptable to use a single value for both the minimum and maximum melt coefficients.

The minimum and maximum snow melt coefficients are used to estimate a melt coefficient that varies by day of the year. The latter is used in the following degree-day equation to compute the melt rate for any particular day:

Melt Rate = (Melt Coefficient) * (Air Temperature – Base Temperature).

Base Temperature
Temperature at which snow begins to melt (degrees F or C).

Fraction Free Water Capacity
The volume of a snow pack's pore space which must fill with melted snow before liquid runoff from the pack begins, expressed as a fraction of snow pack depth.

Initial Snow Depth
Depth of snow at the start of the simulation (water equivalent depth in inches or millimeters).

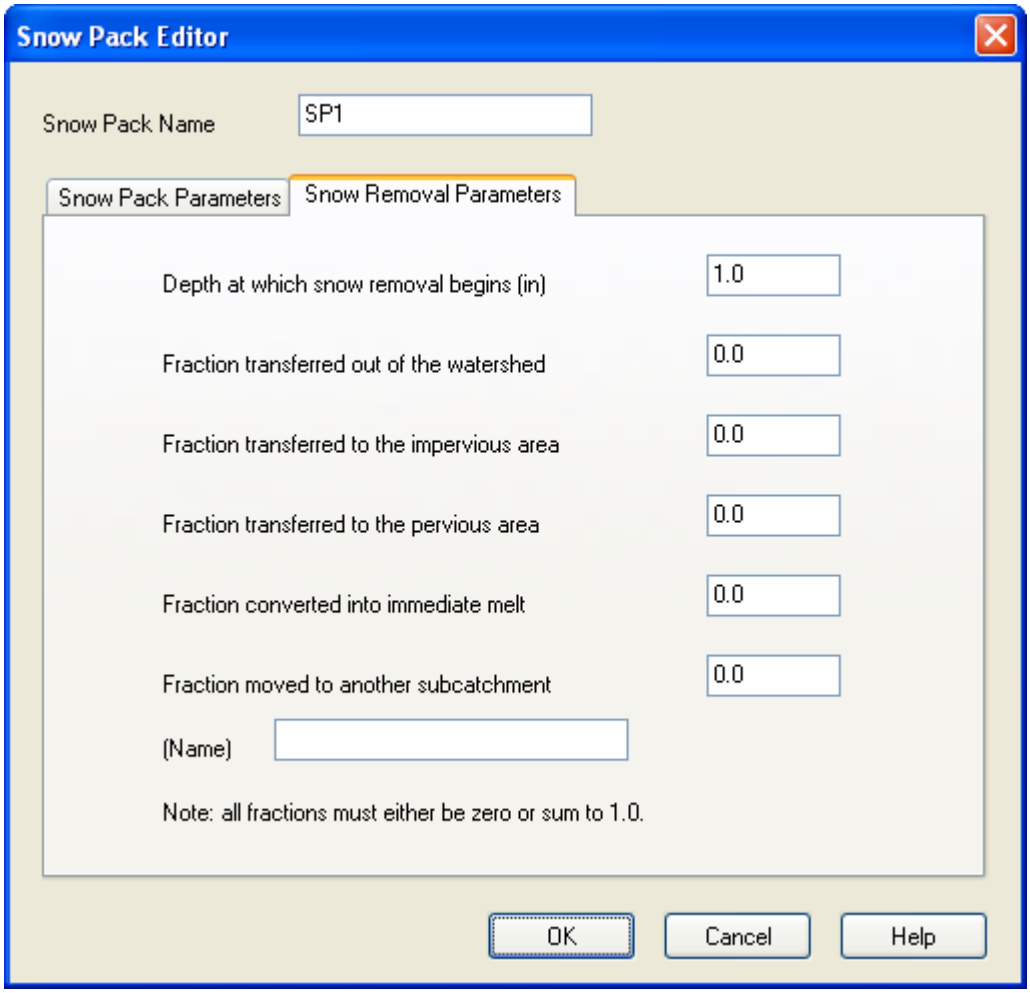
Initial Free Water
Depth of melted water held within the pack at the start of the simulation (inches or mm). This number should be at or below the product of the initial snow depth and the fraction free water capacity.

Depth at 100% Cover
The depth of snow beyond which the entire area remains completely covered and is not subject to any areal depletion effect (inches or mm).

Fraction of Impervious Area That is Plowable
The fraction of impervious area that is plowable and therefore is not subject to areal depletion.

Snow Removal Parameters Page

The Snow Removal page of the Snow Pack Editor describes how snow removal occurs within the Plowable area of a snow pack. The following parameters govern this process:



Depth at which snow removal begins (in or mm)
No removal occurs at depths below this and the fractions specified below are applied to the snow depths in excess of this number.

Fraction transferred out of the watershed
The fraction of excess snow depth that is removed from the system (and does not become runoff).

Fraction transferred to the impervious area
The fraction of excess snow depth that is added to snow accumulation on the pack's impervious area.

Fraction transferred to the pervious area
The fraction of excess snow depth that is added to snow accumulation on the pack's pervious area.

Fraction converted to immediate melt
The fraction of excess snow depth that becomes liquid water which runs onto any subcatchment associated with the snow pack.

Fraction moved to another subcatchment
The fraction of excess snow depth which is added to the snow accumulation on some other subcatchment. The name of the subcatchment must also be provided.

C.14 Time Pattern Editor

The Time Pattern Editor is invoked when a new time pattern object is created or an existing time pattern is selected for editing. The editor contains that following data entry fields:

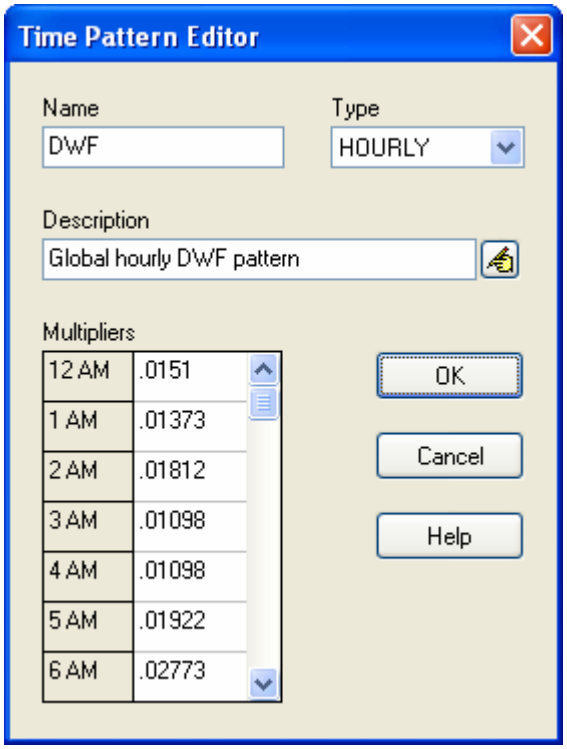
Name
Enter the name assigned to the time pattern.

Type
Select the type of time pattern being specified.

Description
You can provide an optional comment or description for the time pattern. If more than one line is needed, click the button to launch a multi-line comment editor.

Multipliers
Enter a value for each multiplier. The number and meaning of the multipliers changes with the type of time pattern selected:

MONTHLY	One multiplier for each month of the year.
DAILY	One multiplier for each day of the week.
HOURLY	One multiplier for each hour from 12 midnight to 11 PM.
WEEKEND	Same as for HOURLY except applied to weekend days.



In order to maintain an average dry weather flow or pollutant concentration at its specified value (as entered on the Inflows Editor), the multipliers for a pattern should average to 1.0.

C.15 Time Series Editor

The Time Series Editor is invoked whenever a new time series object is created or an existing time series is selected for editing. To use the Time Series Editor:

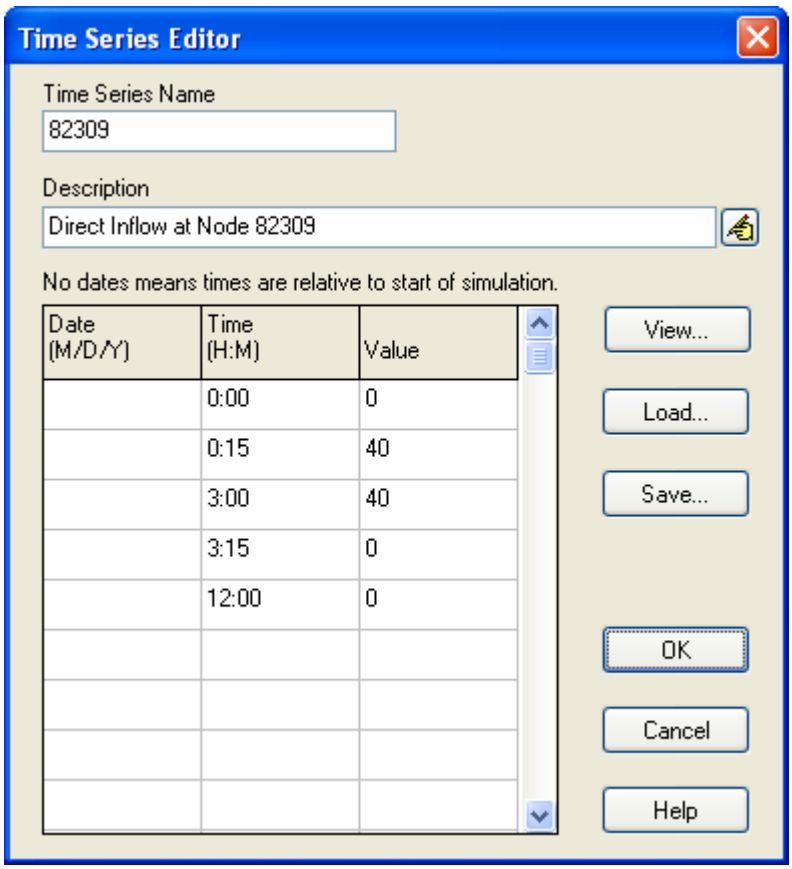
- Enter values for the following data entry fields:

Name	Name of the time series.
Description	Optional comment or description of what the time series represents. Click the button to launch a multi-line comment editor if more than one line is needed.
Date Column	Optional date (in month/day/year format) of the time series values (only needed at points in time where a new date occurs).
Time Column	If dates are used, enter the military time of day for each time series value (as hours:minutes or decimal hours). If dates are not used, enter time as hours since the start of the simulation.
Value Column	The time series' numerical values.

- Click the **View** button to see a graphical plot of the time series data drawn in a separate window.

- If more rows in the data entry grid are needed as the series extends out in time, simply press the **Enter** key when in the last row to append a new row to the grid.

- Right-clicking over the Data Grid will make a popup Edit menu appear. It contains commands to cut, copy, insert, and paste selected cells in the grid as well as options to insert or delete a row.



Note that there are two methods for describing the occurrence time of time series data:

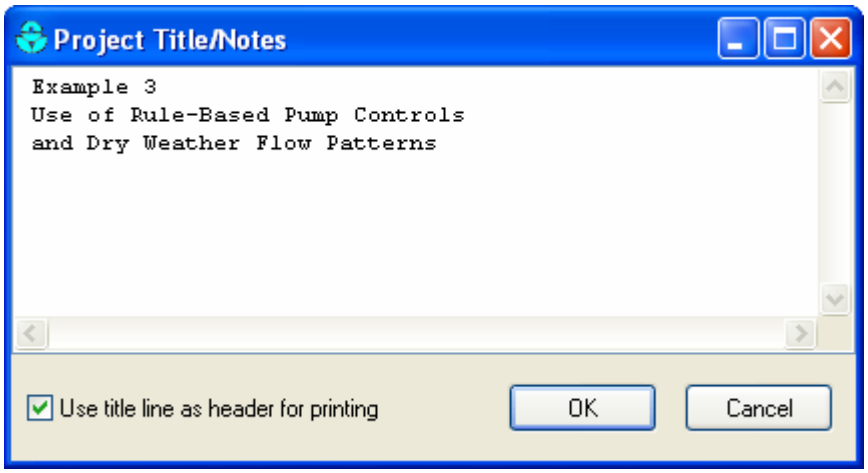
a. as calendar date/time of day (which requires that at least one date, at the start of the series, be entered in the Date column)

b. as elapsed hours since the start of the simulation (where the Date column remains empty).

You can also click the **Load** button to load in a time series that was previously saved to file or click the **Save** button to save the current time series' data to a file.

C.16 Title/Notes Editor

The Title/Notes editor is invoked when a project's Title/Notes data category is selected for editing. As shown below, the editor contains a multi-line edit field where a description of a project can be entered. It also contains a check box used to indicate whether or not the first line of notes should be used as a header for printing.



C.17 Transect Editor

The **Transect Editor** is invoked when a new transect object is created or an existing transect is selected for editing. It contains the following data entry fields:

Name
The name assigned to the transect.

Description
An optional comment or description of the transect.

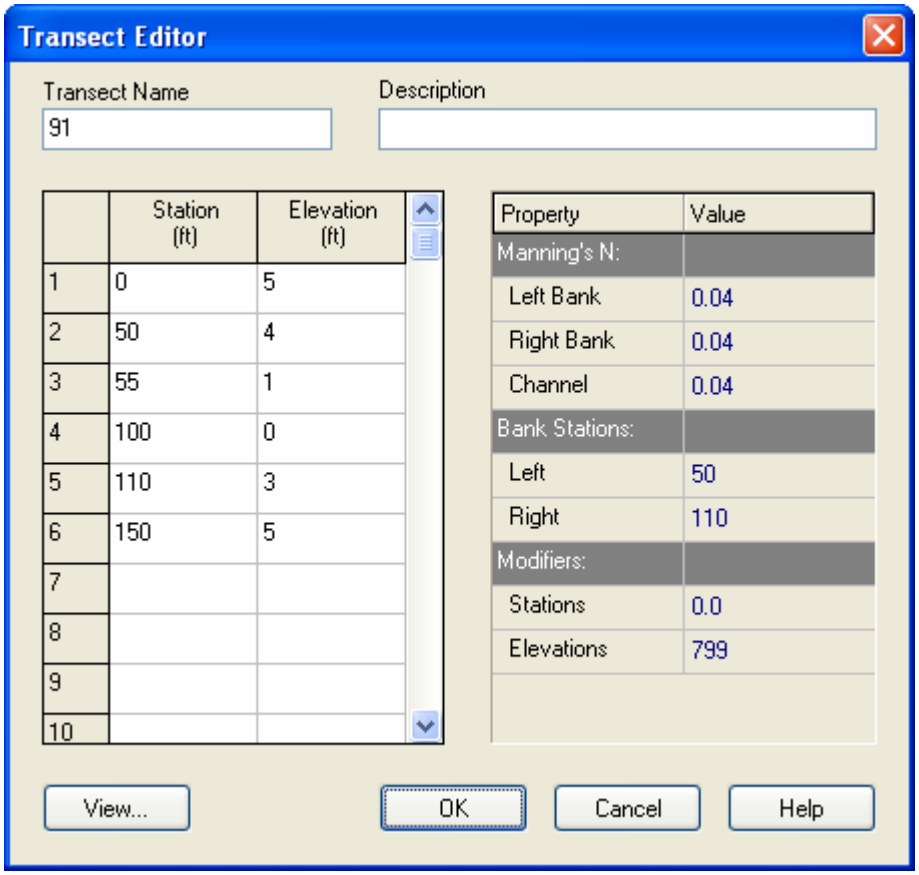
Station/Elevation Data Grid
Values of distance from the left side of the channel along with the corresponding elevation of the channel bottom as one moves across the channel from left to right, looking in the downstream direction. Up to 1500 data values can be entered.

Roughness
Values of Manning's roughness for the left overbank, right overbank, and main channel portion of the transect. The overbank roughness values can be zero if no overbank exists.

Bank Stations
The distance values appearing in the Station/Elevation grid that mark the end of the left overbank and the start of the right overbank. Use 0 to denote the absence of an overbank.

Modifiers
The Stations modifier is a factor by which the distance between each station will be multiplied when the transect data is processed by SWMM. Use a value of 0 if no such

factor is needed. The Elevations modifier is a constant value that will be added to each elevation value.

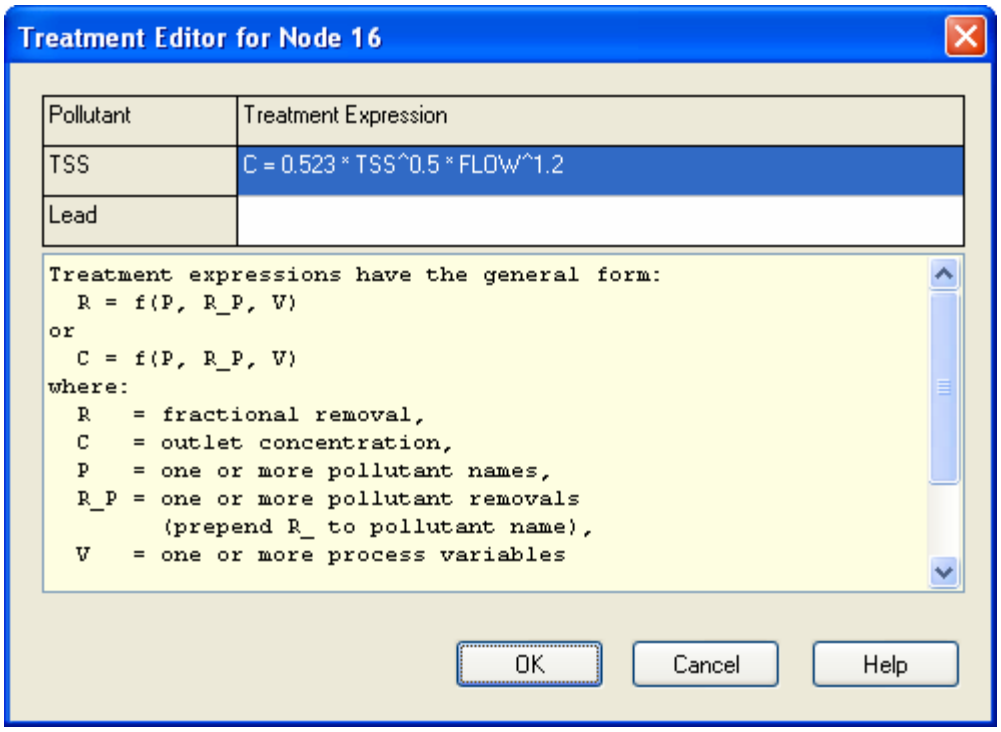


Right-clicking over the Data Grid will make a popup Edit menu appear. It contains commands to cut, copy, insert, and paste selected cells in the grid as well as options to insert or delete a row.

Clicking the **View** button will bring up a window that illustrates the shape of the transect cross section.

C.18 Treatment Editor

The Treatment Editor is invoked whenever the Treatment property of a node is selected from the Property Editor. It displays a list of the project's pollutants with an edit box next to each as shown below.



Enter a valid treatment expression in the box next to each pollutant which receives treatment. Refer to the Treatment topic in Section 3.3 to learn what constitutes a valid treatment expression.

C.19 Unit Hydrograph Editor

The Unit Hydrograph Editor is invoked whenever a new unit hydrograph object is created or an existing one is selected for editing. It is used to specify the shape parameters and rain gage for a group of triangular unit hydrographs. These hydrographs are used to compute rainfall-derived infiltration/inflow (RDII) flow at selected nodes of the drainage system. A UH group can contain up to 12 sets of unit hydrographs (one for each month of the year), and each set can consist of up to 3 individual hydrographs (for short-term, intermediate-term, and long-term responses, respectively). The editor, shown below, contains the following data entry fields:

Name of UH Group
Enter the name assigned to the UH Group.

Rain Gage
Type in (or select from the dropdown list) the name of the rain gage that supplies rainfall data to the unit hydrographs in the group.

Month
Select a month from the list box for which hydrograph parameters will be defined. Select **ALL MONTHS** to specify a default set of hydrographs that apply to all months of the year. Then select specific months that need to have special hydrographs defined.

R-T-K Parameters Grid

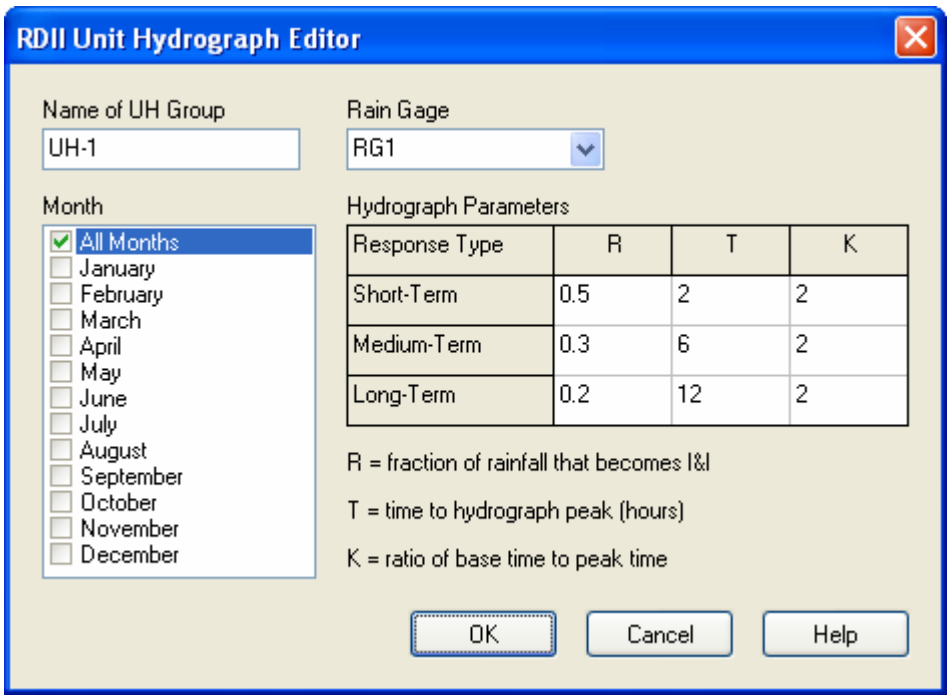
Use this data grid to provide the R-T-K shape parameters for each set of unit hydrographs in selected months of the year. The first row is used to specify parameters for a short-term response hydrograph (i.e., small value of T), the second for a medium-term response hydrograph, and the third for a long-term response hydrograph (largest value of T). It is not required that all three hydrographs be defined. The shape parameters for each UH consist of:

R: the fraction of rainfall volume that enters the sewer system

T: the time from the onset of rainfall to the peak of the UH in hours

K: the ratio of time to recession of the UH to the time to peak

If a grid cell is left empty its corresponding parameter value is assumed to be 0.



Right-clicking over the data grid will make a popup Edit menu appear. It contains commands to cut, copy, and paste text to or from selected cells in the grid.

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APPENDIX D - COMMAND LINE SWMM

D.1 General Instructions

EPA SWMM can also be run as a console application from the command line within a DOS window. In this case the study area data are placed into a text file and results are written to a text file. The command line for running SWMM in this fashion is:

```
swmm5 inpfile rptfile outfile
```

where **inpfile** is the name of the input file, **rptfile** is the name of the output report file, and **outfile** is the name of an optional binary output file that stores results in a special binary format. If the latter file is not needed then just the input and report file names should be supplied. As written, the above command assumes that you are working in the directory in which EPA SWMM was installed or that this directory has been added to the PATH variable in your user profile (or the autoexec.bat file in older versions of Windows). Otherwise full pathnames for the executable swmm5.exe and the files on the command line must be used.

D.2 Input File Format

The input file for command line SWMM has the same format as the project file used by the Windows version of the program. Figure D-1 illustrates an example SWMM5 input file. It is organized in sections, where each section begins with a keyword enclosed in brackets. The various keywords are listed below.

[TITLE]	project title
[OPTIONS]	analysis options
[REPORT]	output reporting instructions
[FILES]	interface file options
[RAINGAGES]	rain gage information
[HYDROGRAPHS]	unit hydrograph data used to construct RDII inflows
[EVAPORATION]	evaporation data
[TEMPERATURE]	air temperature and snow melt data
[SUBCATCHMENTS]	basic subcatchment information
[SUBAREAS]	subcatchment impervious/pervious sub-area data
[INFILTRATION]	subcatchment infiltration parameters
[AQUIFERS]	groundwater aquifer parameters
[GROUNDWATER]	subcatchment groundwater parameters
[SNOWPACKS]	subcatchment snow pack parameters
[JUNCTIONS]	junction node information
[OUTFALLS]	outfall node information

[DIVIDERS]	flow divider node information
[STORAGE]	storage node information
[CONDUITS]	conduit link information
[PUMPS]	pump link information
[ORIFICES]	orifice link information
[WEIRS]	weir link information
[OUTLETS]	outlet link information
[XSECTIONS]	conduit, orifice, and weir cross-section geometry
[TRANSECTS]	transect geometry for conduits with irregular cross-sections
[LOSSES]	conduit entrance/exit losses and flap valves
[CONTROLS]	rules that control pump and regulator operation
[POLLUTANTS]	pollutant information
[LANDUSES]	land use categories
[COVERAGES]	assignment of land uses to subcatchments
[BUILDUP]	buildup functions for pollutants and land uses
[WASHOFF]	washoff functions for pollutants and land uses
[TREATMENT]	pollutant removal functions at conveyance system nodes
[INFLOWS]	external hydrograph/pollutograph inflow at nodes
[DWF]	baseline dry weather sanitary inflow at nodes
[PATTERNS]	periodic variation in dry weather inflow
[RDII]	rainfall-derived I/I information at nodes
[LOADINGS]	initial pollutant loads on subcatchments
[CURVES]	x-y tabular data referenced in other sections
[TIMESERIES]	time series data referenced in other sections

The sections can appear in any arbitrary order in the input file, and not all sections must be present. Each section can contain one or more lines of data. Blank lines may appear anywhere in the file. A semicolon (;) can be used to indicate that what follows on the line is a comment, not data. Data items can appear in any column of a line. Observe how in Figure D-1 these features were used to create a tabular appearance for the data, complete with column headings.

Section keywords can appear in mixed lower and upper case, and only the first four characters (plus the open bracket) are used to distinguish one keyword from another (e.g., [**DIVIDERS**] and [**Divi**] are equivalent). An option is available in the [**OPTIONS**] section to choose flow units from among cubic feet per second (CFS), gallons per minute (GPM), million gallons per day (MGD), cubic meters per second (CMS), liters per second, (LPS), or million liters per day (MLD). If cubic feet or gallons are chosen for flow units, then US units are used for all other quantities. If cubic meters or liters are chosen, then metric units apply to all other quantities. The default flow units are CFS.

A detailed description of the data in each section of the input file will now be given. When listing the format of a line of data, mandatory keywords are shown in boldface while optional items appear in parentheses. A list of keywords separated by a slash (**YES/NO**) means that only one of the words should appear in the data line.

```
[TITLE]
Example SWMM Project

[OPTIONS]
FLOW_UNITS          CFS
INFILTRATION        GREEN_AMPT
FLOW_ROUTING        KINWAVE
START_DATE          8/6/2002
START_TIME          10:00
END_TIME            18:00
WET_STEP            00:15:00
DRY_STEP            01:00:00
ROUTING_STEP        00:05:00


[RAINGAGES]
;;Name     Format     Interval  SCF  DataSource  SourceName
;;==========================================================
GAGE1      INTENSITY  0:15      1.0  TIMESERIES  SERIES1

[EVAPORATION]
CONSTANT  0.02

[SUBCATCHMENTS]
;;Name  Raingage Outlet  Area   %Imperv   Width  Slope
;;=====================================================
AREA1   GAGE1    NODE1   2      80.0      800.0  1.0
AREA2   GAGE1    NODE2   2      75.0      50.0   1.0

[SUBAREAS]
;;Subcatch  N_Imp  N_Perv  S_Imp  S_Perv  %ZER  RouteTo
;;=========================================================
AREA1       0.2   0.02     0.02   0.1     20.0  OUTLET
AREA2       0.2   0.02     0.02   0.1     20.0  OUTLET

[INFILTRATION]
;;Subcatch   Suction   Conduct   InitDef
;;=========================================
AREA1        4.0       1.0       0.34
AREA2        4.0       1.0       0.34

[JUNCTIONS]
;;Name    Elev
;;============
NODE1     10.0
NODE2     10.0
NODE3     5.0
NODE4     5.0
NODE6     1.0
NODE7     2.0

[DIVIDERS]
;;Name    Elev   Link   Type   Parameters
;;=========================================
NODE5     3.0    C6     CUTOFF 1.0
```

Figure D-1. Example SWMM project file (continued on next page).

```
[CONDUITS]
;;Name    Node1     Node2   Length  N        Z1    Z2    Q0
;;==========================================================
C1        NODE1     NODE3   800     0.01     0     0     0
C2        NODE2     NODE4   800     0.01     0     0     0
C3        NODE3     NODE5   400     0.01     0     0     0
C4        NODE4     NODE5   400     0.01     0     0     0
C5        NODE5     NODE6   600     0.01     0     0     0
C6        NODE5     NODE7   400     0.01     0     0     0

[XSECTIONS]
;;Link    Type            G1      G2      G3       G4
;;=================================================
C1        RECT_OPEN       0.5     1       0        0
C2        RECT_OPEN       0.5     1       0        0
C3        CIRCULAR        1.0     0       0        0
C4        RECT_OPEN       1.0     1.0     0        0
C5        PARABOLIC       1.5     2.0     0        0
C6        PARABOLIC       1.5     2.0     0        0

[POLLUTANTS]
;;Name    Units  Cppt  Cgw  Cii  Kd  Snow  CoPollut  CoFract
;;==========================================================
TSS       MG/L   0     0    0    0
Lead      UG/L   0     0    0    0   NO    TSS       0.20

[LANDUSES]
RESIDENTIAL
UNDEVELOPED

[WASHOFF]
;;Landuse       Pollutant   Type   Coeff  Expon  SweepEff  BMPEff
;;==============================================================
RESIDENTIAL     TSS         EMC    23.4   0      0         0
UNDEVELOPED     TSS         EMC    12.1   0      0         0

[COVERAGES]
;;Subcatch     Landuse      Pcnt  Landuse       Pcnt
;;=================================================
AREA1          RESIDENTIAL  80    UNDEVELOPED   20
AREA2          RESIDENTIAL  55    UNDEVELOPED   45

[TIMESERIES]
;Rainfall time series
SERIES1   0:0      0.1    0:15     1.0    0:30  0.5
SERIES1   0:45     0.1    1:00     0.0    2:00  0.0

[REPORT]
INPUT           YES
SUBCATCHMENTS   ALL
NODES           ALL
LINKS           C4    C5   C6
```

Figure D-1. Example SWMM project file (continued from previous page).

Section: [**TITLE**]

Purpose: Attaches a descriptive title to the to the problem being analyzed.

Format: Any number of lines may be entered. The first line will be used as a page header in the output report.

Section: [**OPTIONS**]

Purpose: Provides values for various analysis options.

Format:

FLOW_UNITS	**CFS / GPM / MGD / CMS / LPS / MLD**
INFILTRATION	**HORTON / GREEN_AMPT / CURVE_NUMBER**
FLOW_ROUTING	**STEADY / KINWAVE / DYNWAVE**
ALLOW_PONDING	**YES / NO**
SKIP_STEADY_STATE	**YES / NO**
START_DATE	month/day/year
START_TIME	hours:minutes
END_DATE	month/day/year
END_TIME	hours:minutes
REPORT_START_DATE	month/day/year
REPORT_START_TIME	hours:minutes
SWEEP_START	month/day
SWEEP_END	month/day
DRY_DAYS	days
REPORT_STEP	hours:minutes:seconds
WET_STEP	hours:minutes:seconds
DRY_STEP	hours:minutes:seconds
ROUTING_STEP	seconds
LENGTHENING_STEP	seconds
VARIABLE_STEP	value
INERTIAL_DAMPING	**NONE / PARTIAL / FULL**
NORMAL_FLOW_LIMITED	**YES / NO**
MIN_SURFAREA	value
TEMPDIR	directory

Remarks: **FLOW_UNITS** makes a choice of flow units. Selecting a US flow unit means that all other quantities will be expressed in US units, while choosing a metric flow unit will force all quantities to be expressed in metric units. The default is **CFS**.

INFILTRATION selects a model for computing infiltration of rainfall into the upper soil zone of subcatchments. The default model is **HORTON**.

FLOW_ROUTING determines which method is used to route flows through the drainage system. **STEADY** refers to sequential steady state routing (i.e. hydrograph translation), **KINWAVE** to kinematic wave routing, and **DYNWAVE** to dynamic wave routing. The default routing method is **KINWAVE**.

ALLOW_PONDING determines whether excess water is allowed to collect atop nodes and be re-introduced into the system as conditions permit. The default is NO ponding. In order for ponding to actually occur at a particular node, a non-zero value for its Ponded Area attribute must be used.

SKIP_STEADY_STATE should be set to **YES** if flow routing computations should be skipped during steady state periods of a simulation during which the last set of computed flows will be used. A time step is considered to be in steady state if there has been no significant change in external inflows, storage volumes, and either node water depths (for dynamic wave routing) or conduit flows (for other forms of routing). The default for this option is **NO**.

START_DATE is the date when the simulation begins. If not supplied, a date of 1/1/2002 is used.

START_TIME is the time of day on the starting date when the simulation begins. The default is 12 midnight (0:00:00).

END_DATE is the date when the simulation is to end. The default is the start date.

END_TIME is the time of day on the ending date when the simulation will end. The default is 24:00:00.

REPORT_START_DATE is the date when reporting of results is to begin. The default is the simulation start date.

REPORT_START_TIME is the time of day on the report starting date when reporting is to begin. The default is the simulation start time of day.

SWEEP_START is the day of the year (month/day) when street sweeping operations begin. The default is 1/1.

SWEEP_END is the day of the year (month/day) when street sweeping operations end. The default is 12/31.

DRY_DAYS is the number of days with no rainfall prior to the start of the simulation. The default is 0.

REPORT_STEP is the time interval for reporting of computed results. The default is 0:15:00.

WET_STEP is the time step length used to compute runoff from subcatchments during periods of rainfall or when ponded water still remains on the surface. The default is 0:05:00.

DRY_STEP is the time step length used for runoff computations (consisting essentially of pollutant buildup) during periods when there is no rainfall and no ponded water. The default is 1:00:00.

ROUTING_STEP is the time step length in secinds used for routing flows and water quality constituents through the conveyance system. The default is 600 sec (5 minutes) which should be reduced if using dynamic wave routing. Fractional values (e.g., 2.5) are permissible as are values entered in hours:minutes:seconds format.

LENGTHENING_STEP is a time step, in seconds, used to lengthen conduits under dynamic wave routing, so that they meet the Courant stability criterion under full-flow conditions (i.e., the travel time of a wave will not be smaller than the specified conduit lengthening time step). As this value is decreased, fewer conduits will require lengthening. A value of 0 (the default) means that no conduits will be lengthened.

VARIABLE_STEP is a safety factor applied to a variable time step computed for each time period under dynamic wave flow routing. The variable time step is computed so as to satisfy the Courant stability criterion for each conduit, to prevent an excessive change in water depth at each node, and yet not exceed the **ROUTING_STEP** value. If the safety factor is 0 (the default), then no variable time step is used.

INERTIAL_DAMPING indicates how the inertial terms in the Saint Venant momentum equation will be handled under dynamic wave flow routing. Choosing **NONE** maintains these terms at their full value under all conditions. Selecting **PARTIAL** will reduce the terms as flow comes closer to being critical (and ignores them when flow is supercritical). Choosing **FULL** will drop the terms altogether.

NORMAL_FLOW_LIMITED should be set to **YES** if the criterion used to limit flow in a conduit to normal flow is that the Froude number exceeed 1.0. If set to **NO** (the default) then the normal flow limitation applies only when the water surface slope is less than the conduit invert slope.

MIN_SURFAREA is a minimum surface area used at nodes when computing changes in water depth under dynamic wave routing. If 0 is entered, then the default value of 12.566 ft2 (i.e., the area of a 4-ft diameter manhole) is used.

TEMPDIR provides the name of a file directory (or folder) where SWMM writes its temporary files. If the directory name contains spaces then it should be placed within double quotes. If no directory is specified, then the temporary files are written to the root directory of the current drive.

Section: [**REPORT**]

Purpose: Describes the contents of the report file that is produced.

Formats:

```
INPUT          YES / NO
CONTINUITY     YES / NO
FLOWSTATS      YES / NO
CONTROLS       YES / NO
SUBCATCHMENTS  ALL / NONE / <list of subcatchment names>
NODES          ALL / NONE / <list of node names>
LINKS          ALL / NONE / <list of link names>
```

Remarks: **INPUT** specifies whether or not a summary of the input data should be provided in the output report. The default is **NO**.

CONTINUITY specifies whether continuity checks should be reported or not. The default is **YES**.

FLOWSTATS specifies whether summary flow statistics should be reported or not. The default is **YES**.

CONTROLS specifies whether all control actions taken during a simulation should be listed or not. The default is **NO**.

SUBCATCHMENTS gives a list of subcatchments whose results are to be reported. The default is **NONE**.

NODES gives a list of nodes whose results are to be reported. The default is **NONE**.

LINKS gives a list of links whose results are to be reported. The default is **NONE**.

The **SUBCATCHMENTS**, **NODES**, and **LINKS** lines can be repeated multiple times.

Section: [**FILES**]

Purpose: Identifies optional interface files used or saved by a run.

Formats:

```
USE / SAVE RAINFALL   Fname
USE / SAVE RUNOFF     Fname
USE / SAVE HOTSTART   Fname
USE / SAVE RDII       Fname
USE   INFLOWS         Fname
SAVE  OUTFLOWS        Fname
```

Remarks: *Fname* name of interface file.

Refer to Section 11.7 for a description of interface files. Rainfall, Runoff, and RDII files can either be used or saved in a run, but not both. A run can both use and save a Hotstart file (with different names).

Section: [**RAINGAGES**]

Purpose: Identifies each rain gage that provides rainfall data for the study area.

Formats:

```
Name Form Intvl SCF TIMESERIES Tseries
Name Form Intvl SCF FILE Fname Sta Units
```

Remarks: *Name* name assigned to rain gage.
Form form of recorded rainfall, either **INTENSITY, VOLUME** or **CUMULATIVE**.
Intvl time interval between gage readings in decimal hours or hours:minutes format (e.g., 0:15 for 15-minute readings).
SCF snow catch deficiency correction factor (use 1.0 for no adjustment).
Tseries name of time series in [**TIMESERIES**] section with rainfall data.
Fname name of external file with rainfall data. Rainfall files are discussed in Section 11.3.
Sta name of recording station used in the rain file.
Units rain depth units used in the rain file, either **IN** (inches) or **MM** (millimeters).

Section: [**EVAPORATION**]

Purpose: Specifies how daily evaporation rates vary with time for the study area.

Formats:

```
CONSTANT    evap
MONTHLY     evap1 evap2 ... evap12
TIMESERIES  Tseries
FILE        (pan1 pan2 ... pan12)
```

Remarks: *evap* constant evaporation rate (in/day or mm/day).
evap1 evaporation rate in January (in/day or mm/day).
…
evap12 evaporation rate in December (in/day or mm/day).
Tseries name of time series in [**TIMESERIES**] section with evaporation data.
pan1 pan coefficient for January.
…
pan12 pan coefficient for December.

Use only one of the above formats. If no [**EVAPORATION**] section appears, then evaporation is asumed to be 0.

FILE indicates that evaporation data will be read from the same external climate file used for air temperatures (see below).

Section: [**TEMPERATURE**]

Purpose: Specifies daily air temperatures, monthly wind speed, and various snow melt parameters for the study area . Required only when snow melt is being modeled or when evaporation rates are read from an external climate file.

Formats: **TIMESERIES** *Tseries*
FILE *Fname (Start)*

WINDSPEED MONTHLY *s1 s2 … s11 s12*
WINDSPEED FILE

SNOWMELT *Stemp ATIwt RNM Elev Lat DTLong*
ADC IMPERVIOUS *f.0 f.1 … f.8 f.9*
ADC PERVIOUS *f.0 f.1 … f.8 f.9*

Remarks:

Tseries	name of time series in [**TIMESERIES**] section with temperature data.
Fname	name of external Climate file with temperature data.
Start	date to begin reading from the file in month/day/year format (default is the beginning of the file).
s1	average wind speed in January (mph or km/hr).
…	
s12	average wind speed in December (mph or km/hr).
Stemp	air temperature at which precipitation falls as snow (deg F or C).
ATIwt	antecedent temperature index weight (default is 0.5).
RNM	negative melt ratio (default is 0.6).
Elev	average elevation of study area above mean sea level (ft or m) (default is 0).
Lat	latitude of the study area in degrees North (default is 50).
DTLong	correction, in minutes of time, between true solar time and the standard clock time (default is 0).
f.0	fraction of area covered by snow when ratio of snow depth to depth at 100% cover is 0.
…	
f.9	fraction of area covered by snow when ratio of snow depth to depth at 100% cover is 0.9.

Use the **TIMESERIES** line to read air temperature from a time series or the **FILE** line to read it from an external Climate file. Climate files are discussed in Section 11.4. If neither format is used, then air temperature remains constant at 70 degrees F.

Wind speed can be specified either by monthly average values or by the same Climate file used for air temperature. If neither option appears, then wind speed is assumed to be 0.

Separate Areal Depletion Curves (ADC) can be defined for impervious and pervious sub-areas. The ADC parameters will default to 1.0 (meaning no depletion) if no data are supplied for a particular type of sub-area.

Section: [**SUBCATCHMENTS**]

Purpose: Identifies each subcatchment within the study area. Subcatchments are land area units which generate runoff from rainfall.

Format: *Name Rgage OutID Area %Imperv Width Slope Clength (Spack)*

Remarks:

Name	name assigned to subcatchment.
Rgage	name of rain gage in [**RAINGAGES**] section assigned to subcatchment.
OutID	name of node or subcatchment that receives runoff from subcatchment.
Area	area of subcatchment (acres or hectares).
%Imperv	percent imperviousness of subcatchment.
Width	characteristic width of subcatchment (ft or meters).
Slope	subcatchment slope (percent).
Clength	total curb length (any length units).
Spack	name of snow pack object (from [**SNOWPACKS**] section) that characterizes snow accumulation and melting over the subcatchment.

Section: [**SUBAREAS**]

Purpose: Supplies information about pervious and impervious areas for each subcatchment. Each subcatchment can consist of a pervious sub-area, an impervious sub-area with depression storage, and an impervious sub-area without depression storage.

Format: *Subcat Nimp Nperv Simp Sperv %Zero (RouteTo %Rted)*

Remarks:

Subcat	subcatchment name.
Nimp	Manning's n for overland flow over the impervious sub-area.
Nperv	Manning's n for overland flow over the pervious sub-area.
Simp	depression storage for impervious sub-area (inches or mm).
Sperv	depression storage for pervious sub-area (inches or mm).
%Zero	percent of impervious area with no depression storage.
RouteTo	Use **IMPERVIOUS** if pervious area runoff runs onto impervious area, **PERVIOUS** if impervious runoff runs onto pervious area, or **OUTLET** if both areas drain to the subcatchment's outlet (default = **OUTLET**).
%Rted	Percent of runoff routed from one type of area to another (default = 100).

Section: [**INFILTRATION**]

Purpose: Supplies infiltration parameters for each subcatchment. Rainfall lost to infiltration only occurs over the pervious sub-area of a subcatchment.

Formats:

Subcat MaxRate MinRate Decay DryTime MaxInf
Subcat Suction Conduct InitDef
Subcat CurveNo Conduct DryTime

Remarks:

Subcat	subcatchment name.

For Horton Infiltration:

MaxRate Maximum infiltration rate on Horton curve (in/hr or mm/hr).
MinRate Minimum infiltration rate on Horton curve (in/hr or mm/hr).
Decay Decay rate constant of Horton curve (1/hr).
DryTime Time it takes for fully saturated soil to dry (days).
MaxInf Maximum infiltration volume possible (0 if not applicable) (in or mm).

For Green-Ampt Infiltration:

Suction Soil capillary suction (in or mm).
Conduct Soil saturated hydraulic conductivity (in/hr or mm/hr).
InitDef Initial soil moisture deficit (volume of voids / total volume).

For Curve-Number Infiltration:

CurveNo SCS Curve Number.
Conduct Soil saturated hydraulic conductivity (in/hr or mm/hr).
DryTime Time it takes for fully saturated soil to dry (days).

Section: [**AQUIFERS**]

Purpose: Supplies parameters for each unconfined groundwater aquifer in the study area. Aquifers consist of two zones – a lower saturated zone and an upper unsaturated zone.

Formats: *Name Por WP FC K Ks Ps UEF LED GWR BE WTE UMC*

Remarks:
Name name assigned to aquifer.
Por soil porosity (volumetric fraction).
WP soil wilting point (volumetric fraction).
FC soil field capacity (volumetric fraction).
K saturated hydraulic conductivity (in/hr or mm/hr).
Ks slope of hydraulic conductivity versus moisture content curve (in/hr or mm/hr.
Ps slope of soil tension versus moisture content curve (inches or mm).
UEF fraction of total evaporation available for evapotranspiration in the upper unsaturated zone.
LED maximum depth into the lower saturated zone over which evapotranspiration can occur (ft or m).
GWR rate of percolation from saturated zone to deep groundwater when water table is at ground surface (in/hr or mm/hr).
BE elevation of the bottom of the aquifer (ft or m).
WTE water table elevation at start of simulation (ft or m).
UMC unsaturated zone moisture content at start of simulation (volumetric fraction).

Section: [**GROUNDWATER**]

Purpose: Supplies parameters that determine the rate of groundwater flow between the aquifer underneath a subcatchment and a node of the conveyance system.

Formats: *Subcat Aquifer Node SurfEl A1 B1 A2 B2 A3 TW*

Remarks:

Subcat	subcatchment name.
Aquifer	name of groundwater aquifer underneath the subcatchment.
Node	name of node in conveyance system exchanging groundwater with aquifer.
SurfEl	surface elevation of subcatchment (ft or m).
A1	groundwater flow coefficient (see below).
B1	groundwater flow exponent (see below).
A2	surface water flow coefficient (see below).
B2	surface water flow exponent (see below).
A3	surface water – groundwater interaction coefficient (see below).
TW	fixed depth of surface water at receiving node (ft or m) (set to zero if surface water depth will vary as computed by flow routing).

The flow coefficients are used in the following equation that determines a groundwater flow rate based on groundwater and surface water elevations:

$$Q_{gw} = A1(H_{gw} - E)^{B1} - A2(H_{sw} - E)^{B2} + A3H_{gw}H_{sw}$$

where:
Q_{gw} = groundwater flow (cfs per acre or cms per hectare),
H_{gw} = computed elevation of groundwater table (ft or m),
H_{sw} = computed elevation of surface water at receiving node (ft or m) if *TW* is 0 or TW + E otherwise,
E = fixed elevation of node invert as specified in input (ft or m).

Section: [**SNOWPACKS**]

Purpose: Specifies parameters that govern how snowfall accumulates and melts on the plowable, impervious and pervious surfaces of subcatchments.

Formats:

Name **PLOWABLE** *Cmin Cmax Tbase FWF SD0 FW0 SNN0*
Name **IMPERVIOUS** *Cmin Cmax Tbase FWF SD0 FW0 SD100*
Name **PERVIOUS** *Cmin Cmax Tbase FWF SD0 FW0 SD100*
Name **REMOVAL** *Dplow Fout Fimp Fperv Fimelt (Fsub Scatch)*

Remarks:

Name	name assigned to snowpack parameter set .
Cmin	minimum melt coefficient (in/hr-deg F or mm/hr-deg C).
Cmax	maximum melt coefficient (in/hr-deg F or mm/hr-deg C).
Tbase	snow melt base temperature (deg F or deg C).
FWF	ratio of free water holding capacity to snow depth (fraction).

SD0	initial snow depth (in or mm water equivalent).
FW0	initial free water in pack (in or mm).
SNN0	fraction of impervious area that can be plowed.
SD100	snow depth above which there is 100% cover (in or mm water equivalent).
SDplow	depth of snow on plowable areas at which redistribution through plowing occurs (in or mm).
Fout	fraction of excess snow on plowable area transferred out of watershed.
Fimp	fraction of excess snow on plowable area transferred to impervious area by plowing.
Fperv	fraction of excess snow on plowable area transferred to pervious area by plowing.
Fimelt	fraction of excess snow on plowable area converted into immediate melt.
Fsub	fraction of excess snow on plowable area transferred to pervious area in another subcatchment.
Scatch	name of subcatchment receiving the Fsubcatch fraction of transferred snow.

Use one set of **PLOWABLE**, **IMPERVIOUS**, and **PERVIOUS** lines for each snow pack parameter set created. Snow pack parameter sets are associated with specific subcatchments in the [**SUBCATCHMENTS**] section. Multiple subcatchments can share the same set of snow pack parameters.

The **PLOWABLE** line contains parameters for the impervious area of a subcatchment that is subject to snow removal by plowing but not to areal depletion. This area is the fraction *SNN0* of the total impervious area. The **IMPERVIOUS** line contains parameter values for the remaining impervious area and the **PERVIOUS** line does the same for the entire pervious area. Both of the latter two areas are subject to areal depletion.

The **REMOVAL** line describes how snow removed from the plowable area is transferred onto other areas. The various transfer fractions should either sum to 1.0 or be all 0.0 to indicate that no plowing is done (or the line can simply be omitted).

Section: [**JUNCTIONS**]

Purpose: Identifies each junction node of the drainage system. Junctions are points in space where channels and pipes connect together. For sewer systems they can be either connection fittings or manholes.

Format: *Name Elev (Ymax Y0 Ysur Apond)*

Remarks:

Name	name assigned to junction node.
Elev	elevation of junction invert (ft or m).
Ymax	depth from ground to invert elevation (ft or m) (default is 0).
Y0	water depth at start of simulation (ft or m) (default is 0).

Ysur	maximum additional head above ground elevation that manhole junction can sustain under surcharge conditions (ft or m) (default is 0).
Apond	area subjected to surface ponding once water depth exceeds *Ymax* + *Ysur* (ft2 or m2) (default is 0).

Section: [**OUTFALLS**]

Purpose: Identifies each outfall node (i.e., final downstream boundary) of the drainage system and the corresponding water stage elevation. Only one link can be incident on an outfall node.

Formats:

```
Name  Elev  FREE        Gate
Name  Elev  NORMAL      Gate
Name  Elev  FIXED       Stage   Gate
Name  Elev  TIDAL       Tcurve  Gate
Name  Elev  TIMESERIES  Tseries Gate
```

Remarks:

Name	name assigned to outfall node.
Elev	invert elevation (ft or m).
Stage	elevation of fixed stage outfall (ft or m).
Tcurve	name of curve in [**CURVES**] section containing tidal height (i.e., outfall stage) v. hour of day over a complete tidal cycle.
Tseries	name of time series in [**TIMESERIES**] section that describes how outfall stage varies with time.
Gate	**YES** or **NO** depending on whether a flap gate is present that prevents reverse flow.

Section: [**DIVIDERS**]

Purpose: Identifies each flow divider node of the drainage system. Flow dividers are junctions with exactly two outflow conduits where the total outflow is divided between the two in a prescribed manner.

Formats:

```
Name Elev DivLink OVERFLOW (Ymax Y0 Ysur Apond)
Name Elev DivLink CUTOFF  Qmin (Ymax Y0 Ysur Apond)
Name Elev DivLink TABULAR Dcurve (Ymax Y0 Ysur Apond)
Name Elev DivLink WEIR    Qmin Ht Cd (Ymax Y0 Ysur Apond)
```

Remarks:

Name	name assigned to divider node.
Elev	invert elevation (ft or m).
DivLink	name of link to which flow is diverted.
Qmin	flow at which diversion begins for either a **CUTOFF** or **WEIR** divider (flow units).
Dcurve	name of curve for **TABULAR** divider that relates diverted flow to total flow.
Ht	height of **WEIR** divider (ft or m).

Cd	discharge coefficient for **WEIR** divider.
Ymax	depth from ground to invert elevation (ft or m) (default is 0).
Y0	water depth at start of simulation (ft or m) (default is 0).
Ysur	maximum additional head above ground elevation that node can sustain under surcharge conditions (ft or m) (default is 0).
Apond	area subjected to surface ponding once water depth exceeds *Ymax* + *Ysur* (ft2 or m2) (default is 0).

Section: [**STORAGE**]

Purpose: Identifies each storage node of the drainage system. Storage nodes can have any shape as specified by a surface area versus water depth relation.

Format:
Name Elev Ymax Y0 **TABULAR** *Acurve (Apond Fevap)*
Name Elev Ymax Y0 **FUNCTIONAL** *A1 A2 A0 (Apond Fevap)*

Remarks:

Name	name assigned to storage node.
Elev	invert elevation (ft or m).
Ymax	maximum water depth possible (ft or m).
Y0	water depth at start of simulation (ft or m).
Acurve	name of curve in [**CURVES**] section with surface area (ft2 or m2) as a function of depth (ft or m) for **TABULAR** geometry.
A1	coefficient of **FUNCTIONAL** relation between surface area and depth.
A2	exponenet of **FUNCTIONAL** relation between surface area and depth.
A0	constant of **FUNCTIONAL** relation between surface area and depth.
Apond	surface area subjected to ponding once water depth exceeds *Ymax* (ft2 or m2) (default is 0).
Fevap	fraction of potential evaporation from surface realized (default is 0).

A1, *A2*, and *A0* are used in the following expression that relates surface area (ft2 or m2) to water depth (ft or m) for a storage unit with **FUNCTIONAL** geometry:

$$Area = A0 + A1 \times Depth^{A2}$$

Section: [**CONDUITS**]

Purpose: Identifies each conduit link of the drainage system. Conduits are pipes or channels that convey water from one node to another.

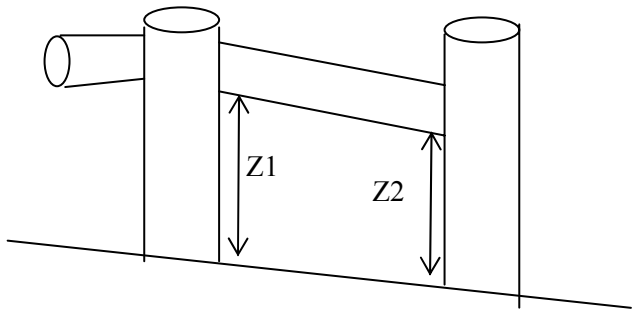
Format: *Name Node1 Node2 Length N Z1 Z2 (Q0)*

Remarks:

Name	name assigned to conduit link.
Node1	name of upstream node.
Node2	name of downstream node.
Length	conduit length (ft or m).

N	value of n (i.e., roughness parameter) in Manning's equation.
Z1	offset height of upstream end of conduit invert above the invert elevation of its upstream node (ft or m).
Z2	offset height of downstream end of conduit invert above the invert elevation of its downstream node (ft or m).
Q0	flow in conduit at start of simulation (flow units) (default is 0).

The figure below illustrates the meaning of the *Z1* and *Z2* parameters.



Section: [**PUMPS**]

Purpose: Identifies each pump link of the drainage system.

Format: *Name Node1 Node2 Pcurve (Status)*

Remarks:

Name	name assigned to pump link.
Node1	name of node on inlet side of pump.
Node2	name of node on outlet side of pump.
Pcurve	name of pump curve listed in the [**CURVES**] section of the input.
Status	status at start of simulation (either **ON** or **OFF**; default is **ON**).

See Section 3.2 for a description of the different types of pumps available.

Section: [**ORIFICES**]

Purpose: Identifies each orifice link of the drainage system. An orifice link serves to limit the flow exiting a node and is often used to model flow diversions.

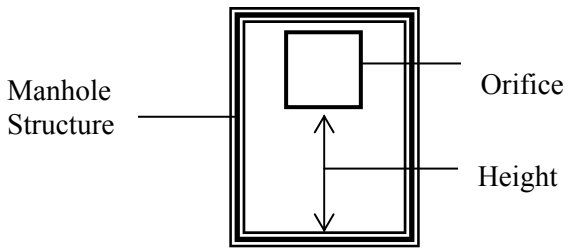
Format: *Name Node1 Node2 Type Height Cd (Flap)*

Remarks:

Name	name assigned to orifice link.
Node1	name of node on inlet end of orifice.
Node2	name of node on outlet end of orifice.
Type	orientation of orifice: either **SIDE** or **BOTTOM**.

Height height of a Side orifice's bottom from invert of inlet node (ft or m) (overriden to 0 for a Bottom orifice).
Cd discharge coefficient (unitless).
Flap **YES** if flap gate present to prevent reverse flow, **NO** if not (deafult is **NO**).

The geometry of an orifice's opening must be described in the [**XSECTIONS**] section. The only allowable shapes are **CIRCULAR** and **RECT_CLOSED** (closed rectangular).



Section: [**WEIRS**]

Purpose: Identifies each weir link of the drainage system. Weirs are used to model flow diversions.

Format: *Name Node1 Node2 Type Height Cd (Flap EC Cd2)*

Remarks: *Name* name assigned to weir link.
Node1 name of node on inlet side of wier.
Node2 name of node on outlet side of weir.
Type **TRANSVERSE, SIDEFLOW, V-NOTCH**, or **TRAPEZOIDAL**.
Height height of weir crest above invert of inlet node (ft or m).
Cd weir discharge coefficient (for CFS if using US flow units or CMS if using metric flow units).
Flap **YES** if flap gate present to prevent reverse flow, **NO** if not (deafult is **NO**).
EC number of end contractions for **TRANSVERSE** or **TRAPEZOIDAL** weir (default is 0).
Cd2 discharge coefficient for triangular ends of a **TRAPEZOIDAL** weir (for CFS if using US flow units or CMS if using metric flow units) (default is value of *Cd*).

The geometry of a weir's opening is described in the [**XSECTIONS**] section. The following shapes must be used with each type of weir:

Weir Type	Cross-Section Shape
Transverse	RECT_OPEN
Sideflow	RECT_OPEN
V-Notch	TRIANGULAR
Trapezoidal	TRAPEZOIDAL

Section: [**OUTLETS**]

Purpose: Identifies each outlet flow control device of the drainage system. These devices are used to model outflows from storage units or flow diversions that have a user-defined relation between flow rate and water depth.

Format:
Name Node1 Node2 Height **TABULAR** *Qcurve (Flap)*
Name Node1 Node2 Height **FUNCTIONAL** *C1 C2 (Flap)*

Remarks:

Name	name assigned to outlet link.
Node1	name of node on inlet end of link.
Node2	name of node on outflow end of link.
Height	minimum water depth at inlet node for outflow to occur (ft or m).
Qcurve	name of rating curve listed in [**CURVES**] section that describes outflow rate (flow units) as a function of head (ft or m) across the outlet for a **TABULAR** outlet.
C1, *C2*	coefficient and exponent, respectively, of power function that relates outflow (Q) to head across the link (H) for a **FUNCTIONAL** outlet (i.e., $Q = C1(H)^{C2}$).
Flap	**YES** if flap gate present to prevent reverse flow, **NO** if not (default is **NO**).

Section: [**XSECTIONS**]

Purpose: Provides cross-section geometric data for conduit and regulator links of the drainage system.

Formats:
Link Shape Geom1 Geom2 Geom3 Geom4 (Barrels)
Link **IRREGULAR** *Tsect*

Remarks:

Link	name of conduit, orifice, or weir.
Shape	cross-section shape (see Table D-1 below for available shapes).
Geom1	maximum depth (ft or m).
Geom2	width parameter (ft or m).
Geom3, *Geom4*	auxiliary parameters (e.g., side slopes). (See Table D-1 for details).
Barrels	number of barrels (i.e., number of parallel pipes of equal size, slope, and roughness) associated with a conduit (default is 1).
Tsect	name of entry in [**TRANSECTS**] section which describes the cross-section geometry of an irregular channel.

Table D-1. Geometric parameters of conduit cross sections.

Shape	Geom1	Geom2	Geom3	Geom4
CIRCULAR	Diameter			
FILLED_CIRCULAR[1]	Diameter	Sediment Depth		
RECT_CLOSED	Height	Top Width		
RECT_OPEN	Height	Top Width		
TRAPEZOIDAL	Height	Base Width	Left Slope	Right Slope
TRIANGULAR	Height	Top Width		
HORIZ_ELLIPSE	Height	Max. Width[2]		
VERT_ELLIPSE	Height	Max. Width[2]		
ARCH (standard)	Size Code[3]			
ARCH (non-standard)	Height	Max. Width		
PARABOLIC	Height	Top Width		
POWER_FUNCTION	Height	Top Width	Exponent	
RECT_TRIANGULAR	Height	Top Width	Triangle Height	
RECT_CIRCULAR	Height	Top Width	Bottom Radius	
MODBASKETHANDLE	Height	Base Width		
EGG	Height			
HORSESHOE	Height			
GOTHIC	Height			
CATENARY	Height			
SEMIELLIPTICAL	Height			
BASKETHANDLE	Height			
SEMICIRCULAR	Height			

[1] A circular conduit partially filled with sediment to a specified depth.
[2] Set to zero to use a standard shaped elliptical pipe as cataloged in the publications mentioned in the footnote below.
[3] As listed in either the "Concrete Pipe Design Manual" published by the American Concrete Pipe Association or "Modern Sewer Design" published by the American Iron and Steel Institute.

Section: [**LOSSES**]

Purpose: Specifies minor head loss coefficients and flap gates for conduits.

Formats: *Conduit Kentry Kexit Kavg (Flap)*

Remarks:

Conduit	name of conduit.
Kentry	entrance minor head loss coefficient.
Kexit	exit minor head loss coefficient.
Kavg	average minor head loss coefficient across length of conduit.
Flap	**YES** if conduit has a flap valve that prevents back flow, **NO** otherwise. (Default is **NO**).

Minor losses are only computed for the Dynamic Wave flow routing option (see [**OPTIONS**] section). They are computed as $Kv^2/2g$ where K = minor loss coefficient, v = velocity, and g = acceleration of gravity. Entrance losses are based on the velocity at the entrance of the conduit, exit losses on the exit velocity, and average losses on the average velocity.

Only enter data for conduits that actually have minor losses or flap valves.

Section: [**TRANSECTS**]

Purpose: Describes the cross-section geometry of natural channels or conduits with irregular shapes following the HEC-2 data format.

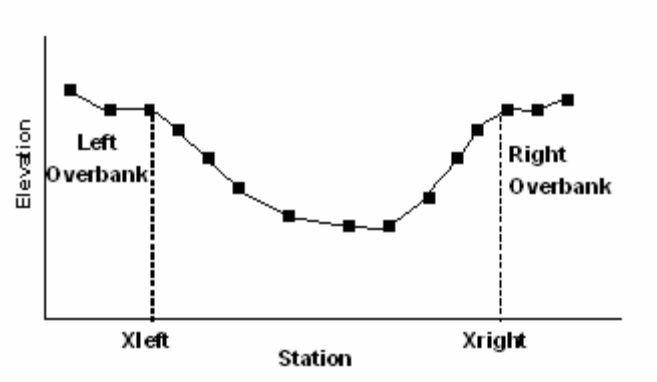
Formats:

```
NC   Nleft   Nright   Nchanl
X1   Name   Nsta   Xleft   Xright   0   0   0   Wfactor   Eoffset
GR   Elev   Station   ...   Elev   Station
```

Remarks:

Nleft	Manning's n of right overbank portion of channel (use 0 if no change from previous **NC** line).
Nright	Manning's n of right overbank portion of channel (use 0 if no change from previous NC line.
Nchanl	Manning's n of main channel portion of channel (use 0 if no change from previous NC line.
Name	name assigned to transect.
Nsta	number of stations across cross-section at which elevation data is supplied.
Xleft	station position which ends the left overbank portion of the channel (ft or m).
Xright	station position which begins the right overbank portion of the channel (ft or m).
Wfactor	factor by which distances between stations should be multiplied to increase (or decrease) the width of the channel (enter 0 if not applicable).
Eoffset	amount added (or subtracted) from the elevation of each station (ft or m).
Elev	elevation of the channel bottom at a cross-section station relative to some fixed reference (ft or m).
Station	distance of a cross-section station from some fixed reference (ft or m).

Transect geometry is described as shown below, assuming that one is looking in a downstream direction:



The first line in this section must always be a **NC** line. After that, the **NC** line is only needed when a transect has different N values than the previous one.

The Manning's n values on the **NC** line will supercede any roughness value entered for the conduit which uses the irregular cross-section.

There should be one **X1** line for each transect. Any number of **GR** lines may follow, and each **GR** line can have any number of Elevation-Station data pairs. (In HEC-2 the **GR** line is limited to 5 stations.)

The station that defines the left overbank boundary on the **X1** line must correspond to one of the station entries on the **GR** lines that follow. The same holds true for the right overbank boundary. If there is no match, a warning will be issued and the program will assume that no overbank area exists.

Section: [**CONTROLS**]

Purpose: Determines how pumps and regulators will be adjusted based on simulation time or conditions at specific nodes and links.

Formats: Each control rule is a series of statements of the form:

```
RULE  ruleID
IF    condition_1
AND   condition_2
OR    condition_3
AND   condition_4
Etc.
THEN  action_1
AND   action_2
Etc.
ELSE  action_3
AND   action_4
Etc.
PRIORITY value
```

Remarks: *RuleID* an ID label assigned to the rule.
condition_n a condition clause.
action_n an action clause.
value a priority value (e.g., a number from 1 to 5).

A condition clause of a Control Rule has the following format:

Object Name Attribute Relation Value

where *Object* is a category of object, *Name* is the object's assigned ID name, *Attribute* is the name of an attribute or property of the object, *Relation* is a relational operator (=, <>, <, <=, >, >=), and *Value* is an attribute value.

Some examples of condition clauses are:

```
NODE  N23  DEPTH  > 10
PUMP  P45  STATUS = OFF
SIMULATION TIME = 12:45:00
```

The objects and attributes that can appear in a condition clause are as follows:

Object	Attributes	Value
NODE	DEPTH HEAD INFLOW	numerical value numerical value numerical value
LINK	FLOW DEPTH	numerical value numerical value
PUMP	STATUS FLOW	ON or OFF numerical value
ORIFICE	SETTING	fraction open
WEIR	SETTING	fraction open
SIMULATION	TIME	elapsed time in decimal hours or hr:min:sec
SIMULATION	DATE CLOCKTIME	month-day-year time of day in hr:min:sec

An action clause of a Control Rule can have one of the following formats:

PUMP *Name* **STATUS** **=** **ON/OFF**
ORIFICE *Name* **SETTING** **=** *Value*
WEIR *Name* **SETTING** **=** *Value*

where *Name* is the name of the link being controlled and **SETTING** refers to the fractional amount that an orifice is fully open or to the fractional amount of the original height between the crest and the top of a weir that remains (i.e., weir control is accomplished by moving the crest height up and down).

Some examples of action clauses are:

```
PUMP P67 STATUS = OFF
ORIFICE O212 SETTING = 0.5
```

Only the **RULE, IF** and **THEN** portions of a rule are required; the other portions are optional.

When mixing **AND** and **OR** clauses, the **OR** operator has higher precedence than **AND**, i.e.,

```
IF A or B and C
```

is equivalent to

```
IF (A or B) and C.
```

If the interpretation was meant to be

```
IF A or (B and C)
```

then this can be expressed using two rules as in

```
IF A THEN ...
IF B and C THEN ...
```

The **PRIORITY** value is used to determine which rule applies when two or more rules require that conflicting actions be taken on a link. A rule without a priority value always has a lower priority than one with a value. For two rules with the same priority value, the rule that appears first is given the higher priority.

Examples:

```
; Simple time-based pump control
RULE R1
IF SIMULATION TIME > 8
THEN PUMP 12 STATUS = ON
ELSE PUMP 12 STATUS = OFF

; Multi-condition orifice gate control
RULE R2A
IF NODE 23 DEPTH > 12
AND LINK 165 FLOW > 100
THEN ORIFICE R55 SETTING = 0.5

RULE R2B
IF NODE 23 DEPTH > 12
AND LINK 165 FLOW > 200
THEN ORIFICE R55 SETTING = 1.0

RULE R2C
IF NODE 23 DEPTH <= 12
OR LINK 165 FLOW <= 100
THEN ORIFICE R55 SETTING = 0

; Pump station operation
RULE R3A
IF NODE N1 DEPTH > 5
THEN PUMP N1A STATUS = ON
```

```
RULE R3B
IF NODE N1 DEPTH > 7
THEN PUMP N1B STATUS = ON

RULE R3C
IF NODE N1 DEPTH <= 3
THEN PUMP N1A STATUS = OFF
AND PUMP N1B STATUS = OFF
```

Section: [**POLLUTANTS**]

Purpose: Identifies the pollutants being analyzed.

Format: *Name Units Crain Cgw Cii Kdecay (Sflag CoPoll CoFract)*

Remarks:

Name	name assigned to pollutant.
Units	concentration units (**MG/L** for milligrams per liter, **UG/L** for micrograms per liter, or **#/L** for direct count per liter).
Crain	concentration of pollutant in rainfall (concentration units).
Cgw	concentration of pollutant in groundwater (concentration units).
Cii	concentration of pollutant in inflow/infiltration (concentration units).
Kdecay	first-order decay coefficient (1/days).
Sflag	**YES** if pollutant buildup occurs only when snowfall occurs, **NO** otherwise (default is **NO**).
CoPoll	name of co-pollutant (default is no co-pollutant).
CoFract	fraction of co-pollutant concentration (default is 0).

FLOW is a reserved word and cannot be used to name a pollutant.

If pollutant buildup is not restricted to times of snowfall and there is no co-pollutant, then the last three parameters can be omitted.

When pollutant X has a co-pollutant Y, it means that fraction CoFract of pollutant Y's runoff concentration is added to pollutant X's runoff concentration when wash off from a subcatchment is computed.

Section: [**LANDUSES**]

Purpose: Identifies the various categories of land uses within the drainage area. Each subcatchment area can be assigned a different mix of land uses. Each land use can be subjected to a different street sweeping schedule.

Format: *Name (SweepInterval Availability LastSweep)*

Remarks:

Name	land use name.
SweepInterval	days between street sweeping.

Availability	fraction of pollutant buildup available for removal by street sweeping.
LastSweep	days since last sweeping at start of the simulation.

Section: [**COVERAGES**]

Purpose: Specifies the percentage of a subcatchment's area that is covered by each category of land use.

Format: *Subcat Landuse Percent Landuse Percent . . .*

Remarks:

Subcat	subcatchment name.
Landuse	land use name.
Percent	percent of subcatchment area.

More than one pair of land use - percentage values can be entered per line. If more than one line is needed, then the subcatchment name must still be entered first on the succeeding lines.

If a land use does not pertain to a subcatchment, then it does not have to be entered.

If no land uses are associated with a subcatchment then no contaminants will appear in the runoff from the subcatchment.

Section: [**BUILDUP**]

Purpose: Specifies the rate at which pollutants build up over different land uses between rain events.

Format: *Landuse Pollutant FuncType C1 C2 C3 PerUnit*

Remarks:

Landuse	land use name.
Pollutant	pollutant name.
FuncType	buildup function type: (**POW / EXP / SAT**).
C1,C2,C3	buildup function parameters (see Table D-2).
PerUnit	**AREA** if buildup is per unit area, **CURBLENGTH** if per length of curb.

Buildup is measured in pounds (kilograms) per unit of area (or curb length) for pollutants whose concentration units are either mg/L or ug/L. If the concentration units are counts/L, then the buildup is expressed as counts per unit of area (or curb length).

Table D-2. Available pollutant buildup functions (t is antecedent dry days).

Name	Function	Equation
POW	Power	Min (C1, C2*t^{C3})
EXP	Exponential	C1*(1 – exp(-C2*t))
SAT	Saturation	C1*t / (C3 + t)

Section: [**WASHOFF**]

Purpose: Specifies the rate at which pollutants are washed off from different land uses during rain events.

Format: *Landuse Pollutant FuncType C1 C2 SweepEffic BMPEffic*

Remarks:

Landuse	land use name.
Pollutant	pollutant name.
FuncType	washoff function type: **EXP / RC / EMC**.
C1, C2	washoff function coefficients(see Table D-3).
SweepEffic	street sweeping removal efficiency (percent) .
BMPEffic	BMP removal efficiency (percent).

Table D-3. Pollutant wash off functions.

Name	Function	Equation	Units
EXP	Exponential	C1 $(runoff)^{C2}$ (buildup)	Mass/hour
RC	Rating Curve	C1 $(runoff)^{C2}$	Mass/sec
EMC	Event Mean Concentration	C1	Mass/Liter

Each washoff function expresses its results in different units.

For the Exponential function the runoff variable is expressed in catchment depth per unit of time (inches per hour or millimeters per hour), while for the Rating Curve function it is in whatever flow units were specified in the [**OPTIONS**] section of the input file (e.g., CFS, CMS, etc.). The buildup parameter in the Exponential function is the current buildup over the subcatchment's land use area in mass units. The units of *C1* in the Exponential function are $(in/hr)^{-C2}$ per hour (or $(mm/hr)^{-C2}$ per hour). For the Rating Curve function, the units of *C1* depend on the flow units employed. For the EMC (event mean concentration) function, *C1* is always in concentration units.

Section: [**TREATMENT**]

Purpose: Specifies the degree of treatment received by pollutants at specific nodes of the drainage system.

Format: *Node Pollut Result* **=** *Func*

Remarks:

Node	Name of node where treatment occurs.
Pollut	Name of pollutant receiving treatment.
Result	Result computed by treatment function. Choices are: **C** – function computes effluent concentration **R** – function computes fractional removal.
Func	mathematical function expressing treatment result in terms of pollutant concentrations, pollutant removals, and other standard variables (see below).

Treatment functions can be any well-formed mathematical expression involving:

- inlet pollutant concentrations (use the pollutant name to represent a concentration)
- removal of other pollutants (use R_ prepended to the pollutant name to represent removal)
- process variables which include:
  FLOW for flow rate into node (user's flow units)
  DEPTH for water depth above node invert (ft or m)
  AREA for node surface area (ft2 or m2)
  DT for routing time step (seconds)
  HRT for hydraulic residence time (hours)

Examples:

```
; 1-st order decay of BOD
Node23  BOD   C = BOD * exp(-0.05*HRT)

; lead removal is 20% of TSS removal
Node23  Lead  R = 0.2 * R_TSS
```

Section: [**DWF**]

Purpose: Specifies dry weather flow and its quality entering the drainage system at specific nodes.

Format: *Node Item Value (Pat1 Pat2 Pat3 Pat4)*

Remarks:

Node	name of node where dry weather flow enters.
Item	keyword **FLOW** for flow or pollutant name for quality constituent.
Value	average baseline value for corresponding *Item* (flow or concentration units).

Pat1,
Pat2,
etc. names of up to four time patterns appearing in the [**PATTERNS**] section.

The actual dry weather input will equal the product of the baseline value and any adjustment factors supplied by the specified patterns. (If not supplied, an adjustment factor defaults to 1.0.)

Section: [**PATTERNS**]

Purpose: Specifies time pattern of dry weather flow or quality in the form of adjustment factors applied as multipliers to baseline values.

Format:

```
Name  MONTHLY   Factor1  Factor2  ...  Factor12
Name  DAILY     Factor1  Factor2  ...  Factor7
Name  HOURLY    Factor1  Factor2  ...  Factor24
Name  WEEKEND   Factor1  Factor2  ...  Factor24
```

Remarks: *Name* name used to identify the pattern.
Factor1,
Factor2,
etc. multiplier values.

The **MONTHLY** format is used to set monthly pattern factors for dry weather flow constituents.

The **DAILY** format is used to set dry weather pattern factors for each day of the week, where Sunday is day 1.

The **HOURLY** format is used to set dry weather factors for each hour of the of the day starting from midnight. If these factors are different for weekend days than for weekday days then the **WEEKEND** format can be used to specify hourly adjustment factors just for weekends.

More than one line can be used to enter a pattern's factors by repeating the pattern's name (but not the pattern type) at the beginning of each additional line.

The pattern factors are applied as multipliers to any baseline dry weather flows or quality concentrations supplied in the [**DWF**] section.

Examples:

```
; Day of week adjustment factors
D1  DAILY  0.5  1.0  1.0  1.0  1.0  1.0  0.5
D2  DAILY  0.8  0.9  1.0  1.1  1.0  0.9  0.8
```

```
; Hourly adjustment factors
H1 HOURLY  0.5 0.6 0.7 0.8 0.8 0.9
H1         1.1 1.2 1.3 1.5 1.1 1.0
H1         0.9 0.8 0.7 0.6 0.5 0.5
H1         0.5 0.5 0.5 0.5 0.5 0.5
```

Section: [**INFLOWS**]

Purpose: Specifies external hydrographs and pollutographs that enter the drainage system at specific nodes.

Formats:
Node **FLOW** *FlowSeries*
Node *Pollut* *PollSeries* *Format* *(ConvFactor)*

Remarks:

Node	name of node where external inflow enters.
FlowSeries	name of time series in [**TIMESERIES**] section describing how external inflows vary with time.
Pollut	name of pollutant.
PollSeries	name of time series describing how external pollutant loading varies with time.
Format	**CONCEN** if pollutant inflow is described as a concentration, **MASS** if it is described as a mass flow rate.
ConvFactor	the factor that converts the inflow's mass flow rate units into the project's mass units per second, where the project's mass units are those specified for the pollutant in the [**POLLUTANTS**] section (see example below).

If an external inflow of a pollutant concentration is specified for a node, then there must also be an external inflow of **FLOW** provided for the same node.

Examples:

```
NODE2    FLOW  N2FLOW
NODE33   TSS   N33TSS  CONCEN

;Mass inflow of BOD in time series N65BOD given in lbs/hr
;(126 converts lbs/hr to mg/sec)
NODE65  BOD  N65BOD  MASS  126
```

Section: [**LOADINGS**]

Purpose: Specifies the pollutant buildup that exists on each subcatchment at the start of a simulation.

Format: *Subcat* *Pollut* *InitBuildup* *Pollut* *InitBuildup* ...

Remarks: *Subcat* name of a subcatchment.
Pollut name of a pollutant.
InitBuildup initial buildup of pollutant (lbs/acre or kg/hectare).

More than one pair of pollutant - buildup values can be entered per line. If more than one line is needed, then the subcatchment name must still be entered first on the succeeding lines.

If an initial buildup is not specified for a pollutant, then its initial buildup is computed by applying the **DRY_DAYS** option (specified in the [**OPTIONS**] section) to the pollutant's buildup function for each land use in the subcatchment.

Section: [**RDII**]

Purpose: Specifies the parameters that describe rainfall-derived infiltration/inflow entering the drainage system at specific nodes.

Format: *Node UHgroup SewerArea*

Remarks: *Node* name of a node.
UHgroup name of an RDII unit hydrograph group specified in the [**HYDROGRAPHS**] section.
SewerArea area of the sewershed which contributes RDII to the node (acres or hectares).

Section: [**HYDROGRAPHS**]

Purpose: Specifies the shapes of the triangular unit hydrographs that determine the amount of rainfall-derived infiltration/inflow (RDII) entering the drainage system.

Formats:
```
Name  Raingage
Name  Month  R1  T1   K1   R2  T2   K2   R3  T3   K3
```

Remarks: *Name* name assigned to a unit hydrograph (UH) group.
Raingage name of rain gage used by UH group.
Month month of the year (e.g., **JAN**, **FEB**, etc. or **ALL** for all months).
R1,R2,R3 response ratios for the short-term, intermediate-term, and long-term UH responses, respectively.
T1,T2,T3 time to peak (hours) for the short-term, intermediate-term, and long-term UH responses, respectively.
K1,K2,K3 recession limb ratios for short-term, intermediate-term, and long-term UH responses, respectively.

For each group of unit hydrographs, use one line to specify its rain gage followed by one or more lines containing UH shape parameters for months with RDII flow. Months not listed are assumed to have no RDII.

The response ratios (R) are the fraction of a unit of rainfall depth that becomes RDII. The sum of the ratios for the three UH's do not have to equal 1.0.

The recession limb ratios (K) are the ratio of the duration of the UH recession limb to the time to peak (T) making the UH time base T*(1+K) hours. The area under each UH is 1 inch (or mm).

Examples: ;All UH sets in this group have the same shapes except those in July

```
UH101  RG1
UH101  ALL 0.033 1.0 2.0 0.033 3.0 2.0 0.033 10.0 2.0
UH101  JUL 0.033 0.5 2.0 0.011 2.0 2.0 0.0 5.0 2.0
```

Section: [**CURVES**]

Purpose: Describes a relationship between two variables in tabular format.

Format: *Name Type X-value Y-value ...*

Remarks:

Name	name assigned to table
Type	**STORAGE / DIVERSION / TIDAL / PUMP1 / PUMP2 / PUMP3 / PUMP4 / RATING**
X-value	an x (independent variable) value
Y-value	the y (dependent variable) value corresponding to x

Multiple pairs of x-y values can appear on a line. If more than one line is needed, repeat the curve's name (but not the type) on subsequent lines. The x-values must be entered in increasing order.

Choices for curve type have the following meanings (flows are expressed in the user's choice of flow units set in the [**OPTIONS**] section):
STORAGE (surface area in ft^2 (m^2) v. depth in ft (m) for a storage unit node)
DIVERSION (diverted outflow v. total inflow for a flow divider node)
TIDAL (water surface elevation in ft (m) v. hour of the day for an outfall node)
PUMP1 (pump outflow v. increment of inlet node volume in ft^3 (m^3))
PUMP2 (pump outflow v. increment of inlet node depth in ft (m))
PUMP3 (pump outflow v. head difference between outlet and inlet nodes in ft (m))
PUMP4 (pump outflow v. continuous depth in ft (m))
RATING (outlet flow v. head in ft (m))

See Section 3.2 for illustrations of the different types of pump curves.

Examples:

```
;Storage curve (x = depth, y = surface area)
AC1  STORAGE  0  1000  2  2000  4  3500  6  4200  8  5000
```

```
;Type1 pump curve (x = inlet wet well volume, y = flow )
PC1  PUMP1
PC1  100  5  300  10  500  20
```

Section: [**TIMESERIES**]

Purpose: Describes how a quantity varies over time.

Formats:
```
Name  ( Date )  Hour  Value  ...
Name  Time  Value  ...
```

Remarks:

Name	name assigned to time series.
Date	date in Month/Day/Year format (e.g., June 15, 2001 would be 6/15/2001).
Hour	24-hour military time (e.g., 8:40 pm would be 20:40) relative to the last date specified (or to midnight of the starting date of the simulation if no previous date was specified).
Time	hours since the start of the simulation, expressed as a decimal number or as Hours:Minutes.
Value	value corresponding to given date and time.

Multiple date-time-value or time-value entries can appear on a line. If more than one line is needed, the table's name must be repeated as the first entry on subsequent lines.

Note that there are two methods for describing the occurrence time of time series data:

- as calendar date/time of day (which requires that at least one date, at the start of the series, be entered)
- as elapsed hours since the start of the simulation.

For the first method, dates need only be entered at points in time when a new day occurs.

Examples:
```
;Rainfall time series with dates specified
TS1 6-15-2001 7:00 0.1 8:00 0.2 9:00 0.05 10:00 0
TS1 6-21-2001 4:00 0.2 5:00 0 14:00 0.1 15:00 0

;Inflow hydrograph - time relative to start of simulation
;(hours can be expressed as decimal hours or hr:min)
HY1  0  0 1.25 100 2:30 150 3.0 120 4.5 0
HY1  32:10 0 34.0 57 35.33 85 48.67 24 50 0
```

D3. Map Data Section

SWMM's graphical user interface (GUI) can display a schematic map of the drainage area being analyzed. This map displays subcatchments as polygons, nodes as circles, links as polylines, and rain gages as bitmap symbols. In addition it can display text labels and a backdrop image, such as a street map. The GUI has tools for drawing, editing,

moving, and displaying these map elements. The map's coordinate data are stored in the format described below. Normally these data are simply appended to the SWMM input file by the GUI so users do not have to concern themselves with it. However it is sometimes more convenient to import map data from some other source, such as a CAD or GIS file, rather than drawing a map from scratch using the GUI. In this case the data can be added to the SWMM project file using any text editor or spreadsheet program. SWMM does not provide any automated facility for converting coordinate data from other file formats into the SWMM map data format.

SWMM's map data are organized into the following seven sections:

[MAP]	X,Y coordinates of the map's bounding rectangle
[POLYGONS]	X,Y coordinates for each vertex of subcatchment polygons
[COORDINATES]	X,Y coordinates for nodes
[VERTICES]	X,Y coordinates for each interior vertex of polyline links
[LABELS]	X,Y coordinates and text of labels
[SYMBOLS]	X,Y coordinates for rain gages
[BACKDROP]	X,Y coordinates of the bounding rectangle and file name of the backdrop image.

Figure D-2 displays a sample map and Figure D-3 the data that describes it. Note that only one link, 3, has interior vertices which give it a curved shape. Also observe that this map's coordinate system has no units, so that the positions of its objects may not necessarily coincide to their real-world locations.

A detailed description of each map data section will now be given. Remember that map data are only used as a visualization aid for SWMM's GUI and they play no role in any of the runoff or routing computations. Map data are not needed for running the command line version of SWMM.

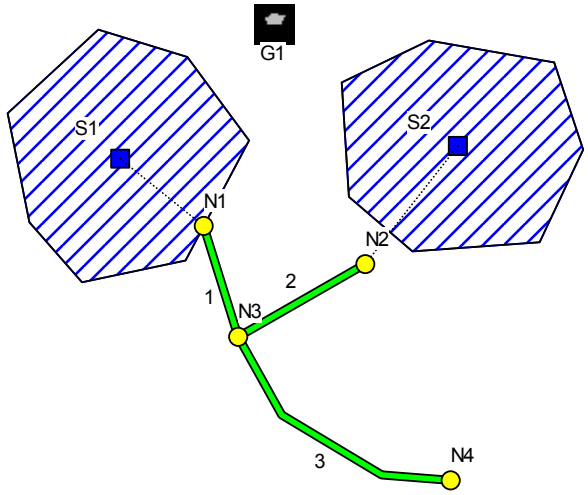


Figure D-2. Example study area map.

```
[MAP]
 DIMENSIONS      0.00   0.00   10000.00  10000.00
 UNITS           None

[COORDINATES]
;;Node              X-Coord         Y-Coord
 N1                 4006.62         5463.58
 N2                 6953.64         4768.21
 N3                 4635.76         3443.71
 N4                 8509.93         827.81

[VERTICES]
;;Link              X-Coord         Y-Coord
 3                  5430.46         2019.87
 3                  7251.66         927.15

[SYMBOLS]
;;Gage              X-Coord         Y-Coord
 G1                 5298.01         9139.07

[Polygons]
;;Subcatchment      X-Coord         Y-Coord
 S1                 3708.61         8543.05
 S1                 4834.44         7019.87
 S1                 3675.50         4834.44
< additional vertices not listed >
 S2                 6523.18         8079.47
 S2                 8112.58         8841.06

[LABELS]
;;X-Coord        Y-Coord         Label
 5033.11         8807.95         "G1"
 1655.63         7450.33         "S1"
 7715.23         7549.67         "S2"
```

Figure D-3. Data for map shown in Figure D-2.

Section: **[MAP]**

Purpose: Provides dimensions and distance units for the map.

Formats: **DIMENSIONS** *X1 Y1 X2 Y2*
UNITS FEET / METERS / DEGREES / NONE

Remarks:

X1	lower-left X coordinate of full map extent
Y1	lower-left Y coordinate of full map extent
X2	upper-right X coordinate of full map extent
Y2	upper-right Y coordinate of full map extent

Section: [**COORDINATES**]

Purpose: Assigns X,Y coordinates to drainage system nodes.

Format: *Node Xcoord Ycoord*

Remarks: *Node* name of node.
Xcoord horizontal coordinate relative to origin in lower left of map.
Ycoord vertical coordinate relative to origin in lower left of map.

Section: [**VERTICES**]

Purpose: Assigns X,Y coordinates to interior vertex points of curved drainage system links.

Format: *Link Xcoord Ycoord*

Remarks: *Link* name of link.
Xcoord horizontal coordinate of vertex relative to origin in lower left of map.
Ycoord vertical coordinate of vertex relative to origin in lower left of map.

Include a separate line for each interior vertex of the link, ordered from the inlet node to the outlet node.

Straight-line links have no interior vertices and therefore are not listed in this section.

Section: [**POLYGONS**]

Purpose: Assigns X,Y coordinates to vertex points of polygons that define a subcatchment boundary.

Format: *Subcat Xcoord Ycoord*

Remarks: *Subcat* name of subcatchment.
Xcoord horizontal coordinate of vertex relative to origin in lower left of map.
Ycoord vertical coordinate of vertex relative to origin in lower left of map.

Include a separate line for each vertex of the subcatchment polygon, ordered in a consistent clockwise or counter-clockwise sequence.

Section: [**SYMBOLS**]

Purpose: Assigns X,Y coordinates to rain gage symbols.

Format: *Gage Xcoord Ycoord*

Remarks: *Gage* name of rain gage.

Xcoord	horizontal coordinate relative to origin in lower left of map.
Ycoord	vertical coordinate relative to origin in lower left of map.

Section: [**LABELS**]

Purpose: Assigns X,Y coordinates to user-defined map labels.

Format: *Xcoord Ycoord Label (Anchor Font Size Bold Italic)*

Remarks:

Xcoord	horizontal coordinate relative to origin in lower left of map.
Ycoord	vertical coordinate relative to origin in lower left of map.
Label	text of label surrounded by double quotes.
Anchor	name of node or subcatchment that anchors the label on zoom-ins (use an empty pair of double quotes if there is no anchor).
Font	name of label's font (surround by double quotes if the font name includes spaces).
Size	font size in points.
Bold	**YES** for bold font, **NO** otherwise.
Italic	**YES** for italic font, **NO** otherwise.

Use of the anchor node feature will prevent the label from moving outside the viewing area when the map is zoomed in on.

If no font information is provided then a default font is used to draw the label.

Section: [**BACKDROP**]

Purpose: Specifies file name and coordinates of map's backdrop image.

Formats:

FILE *Fname*
DIMENSIONS *X1 Y1 X2 Y2*

Remarks:

Fname	name of file containing backdrop image
X1	lower-left X coordinate of backdrop image
Y1	lower-left Y coordinate of backdrop image
X2	upper-right X coordinate of backdrop image
Y2	upper-right Y coordinate of backdrop image

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APPENDIX E - ERROR MESSAGES

ERROR 101: memory allocation error.
There is not enough physical memory in the computer to analyze the study area.

ERROR 103: cannot solve KW equations for Link xxx.
The internal solver for Kinematic Wave routing failed to converge for the specified link at some stage of the simulation.

ERROR 105: cannot open ODE solver.
The system could not open its Ordinary Differential Equation solver.

ERROR 107: cannot compute a valid time step.
A valid time step for runoff or flow routing calculations (i.e., a number greater than 0) could not be computed at some stage of the simulation.

ERROR 108: ambiguous outlet ID name for Subcatchment xxx.
The name of the element identified as the outlet of a subcatchment belongs to both a node and a subcatchment in the project's data base.

ERROR 109: invalid parameter values for Aquifer xxx.
The properties entered for an aquifer object were either invalid numbers or were inconsistent with one another (e.g., the soil field capacity was higher than the porosity).

ERROR 111: invalid length for Conduit xxx.
Conduits cannot have zero or negative lengths.

ERROR 113: invalid roughness for Conduit xxx.
Conduits cannot have zero or negative roughness values.

ERROR 114: invalid number of barrels for Conduit xxx.
Conduits must consist of one or more barrels.

ERROR 115: adverse slope for Conduit xxx.
Under Steady or Kinematic Wave routing, all conduits must have positive slopes. This can usually be corrected by reversing the inlet and outlet nodes of the conduit (i.e., right click on the conduit and select **Reverse** from the popup menu that appears). Adverse slopes are permitted under Dynamic Wave routing.

ERROR 117: no cross section defined for Link xxx.
A cross section geometry was never defined for the specified link.

ERROR 119: invalid cross section for Link xxx.
Either an invalid shape or invalid set of dimensions was specified for a link's cross section.

ERROR 121: missing or invalid pump curve assigned to Pump xxx.
Either no pump curve or an invalid type of curve was specified for a pump.

ERROR 131: the following links form cyclic loops in the drainage system.
The Steady and Kinematic Wave flow routing methods cannot be applied to systems where a cyclic loop exists (i.e., a directed path along a set of links that begins and ends at the same node). The same is true for Dynamic Wave routing where water quality analysis is performed. Most often the cyclic nature of the loop can be eliminated by reversing the direction of one of its links (i.e., switching the inlet and outlet nodes of the link). The names of the links that form the loop will be listed following this message.

ERROR 133: Node xxx has more than one outlet link.
Under Steady and Kinematic Wave flow routing, a junction node can have only a single outlet link.

ERROR 134: Node xxx has more than one DUMMY outlet link.
Only a single conduit with a DUMMY cross-section can be directed out of a node.

ERROR 135: Divider xxx does not have two outlet links.
Flow divider nodes must have two outlet links connected to them.

ERROR 136: Divider xxx has invalid diversion link.
The link specified as being the one carrying the diverted flow from a flow divider node was defined with a different inlet node.

ERROR 137: Weir Divider xxx has invalid parameters.
The parameters of a Weir-type divider node either are non-positive numbers or are inconsistent (i.e., the value of the discharge coefficient times the weir height raised to the 3/2 power must be greater than the minimum flow parameter).

ERROR 138: Node xxx has initial depth greater than maximum depth.
Self-explanatory.

ERROR 139: Regulator xxx is the outlet of a non-storage node.
Under Steady or Kinematic Wave flow routing, orifices, weirs, and outlet links can only be used as outflow links from storage nodes.

ERROR 141: Outfall xxx has more than 1 inlet link or an outlet link.
An outfall node is only permitted to have one link attached to it.

ERROR 143: Regulator xxx has invalid cross-section shape.
An orifice must have either a CIRCULAR or RECT_CLOSED shape, while a weir must have either a RECT_OPEN, TRAPEZOIDAL, or TRIANGULAR shape.

ERROR 145: Drainage system has no acceptable outlet nodes.
Under Dynamic Wave flow routing, there must be at least one node designated as an outfall.

ERROR 151: a Unit Hydrograph in set xxx has invalid time base.
The time base of a Unit hydrograph must be greater than 0.

ERROR 153: a Unit Hydrograph in set xxx has invalid response ratios.
The response ratios for a set of Unit Hydrographs (the short-, medium-, and long-term response hydrographs) must be between 0 and 1.0 and cannot add up to a value greater than 1.0

ERROR 155: invalid sewer area for RDII at Node xxx.
The sewer area contributing RDII inflow to a node cannot be a negative number.

ERROR 161: cyclic dependency in treatment functions at Node xxx.
An example would be where the removal of pollutant 1 is defined as a function of the removal of pollutant 2 while the removal of pollutant 2 is defined as a function of the removal of pollutant 1.

ERROR 171: Curve xxx has its data out of sequence.
The X-values of a curve object must be entered in increasing order.

ERROR 173: Time Series xxx has its data out of sequence.
The time (or date/time) values of a time series must be entered in sequential order.

ERROR 191: simulation start date comes after ending date.
Self-explanatory.

ERROR 193: report start date comes after ending date.
Self-explanatory.

ERROR 195: reporting time step is less than routing time step.
Self-explanatory.

ERROR 200: one or more errors in input file.
This message appears when one or more input file parsing errors (the 200-series errors) occur.

ERROR 201: too many characters in input line.
A line in the input file cannot exceed 1024 characters.

ERROR 203: too few items at line n of input file.
Not enough data items were supplied on a line of the input file.

ERROR 205: invalid keyword at line n of input file.
An unrecognized keyword was encountered when parsing a line of the input file.

ERROR 207: duplicate ID name at line n of input file.
An ID name used for an object was already assigned to an object of the same category.

ERROR 209: undefined object xxx at line n of input file.
A reference was made to an object that was never defined. An example would be if node 123 were designated as the outlet point of a subcatchment, yet no such node was ever defined in the study area.

ERROR 211: invalid number xxx at line n of input file.
Either a string value was encountered where a numerical value was expected or an invalid number (e.g., a negative value) was supplied.

ERROR 213: invalid date/time xxx at line n of input file.
An invalid format for a date or time was encountered. Dates must be entered as month/day/year and times as either decimal hours or as hour:minute:second.

ERROR 217: control rule clause out of sequence at line n of input file.
Errors of this nature can occur when the format for writing control rules is not followed correctly (see Section C.3).

ERROR 219: data provided for unidentified transect at line n of input file.
A **GR** line with Station-Elevation data was encountered in the [`TRANSECTS`] section of the input file after an **NC** line but before any **X1** line that contains the transect's ID name.

ERROR 221: transect station out of sequence at line n of input file.
The station distances specified for the transect of an irregular cross section must be in increasing numerical order starting from the left bank.

ERROR 223: Transect xxx has too few stations.
A transect for an irregular cross section must have at least 2 stations defined for it.

ERROR 225: Transect xxx has too many stations.
A transect cannot have more than 1500 stations defined for it.

ERROR 227: Transect xxx has no Manning's N.
No Manning's N was specified for a transect (i.e., there was no **NC** line in the [`TRANSECTS`] section of the input file.

ERROR 229: Transect xxx has invalid overbank locations.
The distance values specified for either the left or right overbank locations of a transect do not match any of the distances listed for the transect's stations.

ERROR 231: Transect xxx has no depth.
All of the stations for a transect were assigned the same elevation.

ERROR 233: invalid treatment function expression at line n of input file.
A treatment function supplied for a pollutant at a specific node is either not a correctly formed mathematical expression or refers to unknown pollutants, process variables, or math functions.

ERROR 301: files share same names.
The input, report, and binary output files specified on the command line cannot have the same names.

ERROR 303: cannot open input file.
The input file either does not exist or cannot be opened (e.g., it might be in use by another program).

ERROR 305: cannot open report file.
The report file cannot be opened (e.g., it might reside in a directory to which the user does not have write privileges).

ERROR 307: cannot open binary results file.
The binary output file cannot be opened (e.g., it might reside in a directory to which the user does not have write privileges).

ERROR 309: error writing to binary results file.
There was an error in trying to write results to the binary output file (e.g., the disk might be full or the file size exceed the limit imposed by the operating system).

ERROR 311: error reading from binary results file.
The command line version of SWMM could not read results saved to the binary output file when writing results to the report file.

ERROR 313: cannot open scratch rainfall interface file.
SWMM could not open the temporary file it uses to collate data together from external rainfall files.

ERROR 315: cannot open rainfall interface file xxx.
SWMM could not open the specified rainfall interface file, possibly because it does not exist or because the user does not have write privileges to its directory.

ERROR 317: cannot open rainfall data file xxx.
An external rainfall data file could not be opened, most likely because it does not exist.

ERROR 319: invalid format for rainfall interface file.
SWMM was trying to read data from a designated rainfall interface file with the wrong format (i.e., it may have been created for some other project or actually be some other type of file).

ERROR 321: no data in rainfall interface file for gage xxx.
This message occurs when a project wants to use a previously saved rainfall interface file, but cannot find any data for one of its rain gages in the interface file.

ERROR 323: cannot open runoff interface file xxx.
A runoff interface file could not be opened, possibly because it does not exist or because the user does not have write privileges to its directory.

ERROR 325: incompatible data found in runoff interface file.
SWMM was trying to read data from a designated runoff interface file with the wrong format (i.e., it may have been created for some other project or actually be some other type of file).

ERROR 327: attempting to read beyond end of runoff interface file.
This error can occur when a previously saved runoff interface file is being used in a simulation with a longer duration than the one that created the interface file.

ERROR 329: error in reading from runoff interface file.
A format error was encountered while trying to read data from a previously saved runoff interface file.

ERROR 330: hotstart interface files have same names.
In cases where a run uses one hotstart interface file to start a simulation and another to save results at the end of the simulation, the two files cannot both have the same name.

ERROR 331: cannot open hotstart interface file xxx.
A hotstart interface file could not be opened, possibly because it does not exist or because the user does not have write privileges to its directory.

ERROR 333: incompatible data found in hotstart interface file.
SWMM was trying to read data from a designated hotstart interface file with the wrong format (i.e., it may have been created for some other project or actually be some other type of file).

ERROR 335: error in reading from hotstart interface file.
A format error was encountered while trying to read data from a previously saved hotstart interface file.

ERROR 336: no climate file specified for evaporation and/or wind speed.
This error occurs when the user specifies that evaporation or wind speed data will be read from an external climate file, but no name is supplied for the file.

ERROR 337: cannot open climate file xxx.
An external climate data file could not be opened, most likely because it does not exist.

ERROR 338: error in reading from climate file xxx.
SWMM was trying to read data from an external climate file with the wrong format.

ERROR 339: attempt to read beyond end of climate file xxx.
The specified external climate does not include data for the period of time being simulated.

ERROR 341: cannot open scratch RDII interface file.
SWMM could not open the temporary file it uses to store RDII flow data.

ERROR 343: cannot open RDII interface file xxx.
An RDII interface file could not be opened, possibly because it does not exist or because the user does not have write privileges to its directory.

ERROR 345: invalid format for RDII interface file.
SWMM was trying to read data from a designated RDII interface file with the wrong format (i.e., it may have been created for some other project or actually be some other type of file).

ERROR 351: cannot open routing interface file xxx.
A routing interface file could not be opened, possibly because it does not exist or because the user does not have write privileges to its directory.

ERROR 353: invalid format for routing interface file xxx.
SWMM was trying to read data from a designated routing interface file with the wrong format (i.e., it may have been created for some other project or actually be some other type of file).

ERROR 355: mis-matched names in routing interface file xxx.
The names of pollutants found in a designated routing interface file do not match the names used in the current project.

ERROR 357: inflows and outflows interface files have same name.
In cases where a run uses one routing interface file to provide inflows for a set of locations and another to save outflow results, the two files cannot both have the same name.

APPENDIX C

Chain of Custody

Chain of Custody No. 55015

Multiple COC's **Yes** **No**

_____ _____ _____

ChemServe ENVIRONMENTAL ANALYSTS

317 Elm Street Milford, NH 03055
(603) 673-5440/ Fax (603) 673-0366

CHAIN OF CUSTODY

Ⓐ CUSTOMER INFORMATION

CUSTOMER: _____

ADDRESS: _____

CITY/STATE/ZIP _____

TELEPHONE: _____

REPORT TO: _____

P O NUMBER: _____

Ⓑ PROJECT INFORMATION

JOB NAME: _____

JOB NUMBER: _____

LOCATION: _____

TELEPHONE: _____

CONTACT: _____

QUOTE NUMBER: _____

Ⓒ SAMPLE INFORMATION

TURNAROUND TIME: (CIRCLE ONE:)

STANDARD RUSH

RUSH T.A.T. _____ (CHECK w/LAB)

AMBER GLASS (AG) / GLASS (G) / PLASTIC (P)

STATION # Ⓓ	SAMPLE IDENTIFICATION & LOCATION Ⓔ	COLLECTED Ⓕ DATE	COLLECTED Ⓖ TIME	SAMPLE TYPE Ⓗ GRAB	SAMPLE TYPE Ⓗ COMP	Ⓘ MATRIX SOLID (S) LIQUID (L) COMBINED (C) HAZARD (H)	Ⓙ # OF CONTAINERS	Ⓚ CONTAINER AND PRESERVATIVE										Ⓛ ANALYSIS
		DATE	TIME															
		DATE	TIME															
		DATE	TIME															
		DATE	TIME															
		DATE	TIME															
		DATE	TIME															
		DATE	TIME															
		DATE	TIME															

Ⓜ CUSTODY

SAMPLER: _____
(print name)

SIGNATURE:

	DATE	MILITARY TIME
RELINQUISHED:	DATE	TIME
RECEIVED:	DATE	TIME
RELINQUISHED:	DATE	TIME
RECEIVED FOR LAB:	DATE	TIME

SAMPLE CHECK LIST:

RECEIVED WITHIN HOLD TIME YES OR NO

RECEIVED IN GOOD CONDITION YES OR NO

TEMP BLANK _____ °C

SHIPPED OR HAND DELIVERED

SAMPLES WERE PROPERLY PRESERVED YES NO N/A

SAMPLES WERE FILTERED IN FIELD LAB N/A

IF NO EXPLAIN:

GROUP #

FIELD READING(S):

CHAIN OF CUSTODY RECORD

R.I. Analytical Laboratories, Inc.

41 Illinois Avenue
Warwick, RI 02888
Tel: 800-937-2580
Fax: 401-738-1970

131 Coolidge St, Bldg. 2
Hudson, MA 01749
Tel: 888-228-3334
Fax: 978-568-0078

Date Collected	Time Collected	Field Sample Identification	Grab or Composite	# of Containers & Type [T]	Preservation Code [P]	Matrix Code [M]

Client Information	
Company Name:	
Address:	
City / State / Zip:	
Telephone:	Fax:
Contact Person:	

Project Information		
Project Name:		
P.O. Number:	Project Number:	
Report To:	Phone:	Fax:
Sampled by:		
Quote No:	Email address:	

Relinquished By	Date	Time	Received By	Date	Time

Turn Around Time			
	Normal		EMAIL Report
	5 Business days. Possible surcharge.		
	Rush _____ (business days)		

Project Comments

Circle if applicable: GW-1, GW-2, GW-3, S-1, S-2, S-3 MCP Data Enhancement QC Package? Yes No

Lab Use Only	
	Sample Pick Up Only
	RIAL sampled; attach field hours
	Shipped on ice
Workorder No:	

Container Types: P=Poly, G=Glass, AG=Amber Glass, V=Vial, St=Sterile

Preservation Codes: NP=None, N=HNO_3, H=HCl, S=H_2SO_4, SH=NaOH, SB=$NaHSO_4$, M=MeOH, T=$Na_2S_2O_3$, Z=ZnOAc, I=Ice

Matrix Codes: GW=Groundwater, SW=Surface Water, WW=Wastewater, DW=Drinking Water, S=Soil, Sl=Sludge, A=Air, B=Bulk/Solid, O=_____

APPENDIX D

Stormwater Sampling SOP

Stormwater Sampling Standard Operating Procedure (SOP)

Sampling Process

The goals of the stormwater sampling events are to collect inlet and outlet samples from six existing BMPs to determine the amount of pollutants removed by the specific BMP and thus prevented from entering the ponds.

This Standard Operating Procedures (SOP) will be used as a guide for proper procedures when making field observations, sampling and handling stormwater, managing data, and completing quality control measures.

Stormwater samples will only be collected when the following conditions are met:

- Sampling must be preceded by 72 hours of dry weather. The NOAA: National Weather Service Website will be used current weather conditions and forecasts.
- Storm events that are anticipated to generate >0.5" of precipitation in a 24-hr period.

Field Activities

Field sampling activities will include inlet and outlet stormwater sample collection after the storm event. The following procedures were developed to ensure that data collection remains consistent and accurate throughout the project.

Field Equipment Preparation

Preparation of field equipment necessary for collecting stormwater samples will occur prior to the sampling event. All maintenance and repairs to the equipment will be completed at this time to prevent any impediment of the fieldwork.

Inspection / Acceptance Requirements for Supplies and Consumables

Field supplies and consumables will be inspected prior to use. Pennichuck will obtain sample bottles from the laboratory prepared with the appropriate preservations prior to the sampling event. Sample bottles will be needed for each of the six sampling locations (inlet and outlet), sample duplicate, plus extras. Sample bottles will be checked prior to use for cracks, leaks, and potential contamination. Should any bottle be deemed inadequate, it will be appropriately discarded. Back-up sample containers will be available during each sampling event. Distilled water will be obtained from a source of known quality and stored in appropriately labeled containers. Distilled water containers will be inspected in the same manner as the sample bottles and discarded if contamination occurs.

Equipment Decontamination Procedures

Automated Sampler

1. Drain sample containers and rinse thoroughly with deionized water
2. Rinse intake line thoroughly with deionized water
3. Rinse with deionized water
4. Place intake line back into sampler

Observations and Field Records

Field Data Sheets will be completed on-site at the time of sampling and monitoring and will include the following information:

- Site name and location
- Names of field team personnel
- Sample date/time collection
- Weather conditions
- Site observations
- Station location
- Sample ID #
- QA/QC issues

Stormwater Sample Collection Procedures

Stormwater samples will be collected at the inlet and outlet of each stormwater sampling location. Stormwater sampling will be collected during first flush conditions (when pollutant concentration is greatest). Samples will be collected at a designated time from when stormwater flow occurs at the sample location as summarized in the table below. Automatic stormwater samplers will be installed at the inlet and outlet of each BMP. SW-3 will require a different setup to collect samples.

Site	BMP Type	Land Use	Location	Sample Collection Time
SW-1	Wet Pond	Low Density Residential	Greenleaf St, (near HD)	30.17 minutes after flow is detected.
SW-2	Grass Detention Pond	Commercial	Home Depot	30.21 minutes after flow is detected.
SW-3	Infiltration – LID	Commercial	Pennichuck Square	0.74 minutes after flow is detected.
SW-4	Forebay/Swale	Commercial	Celina Avenue	14.78 minutes after flow is detected.
SW-5	Detention Pond w/ wetland Plants	Residential	White Oak Drive (Near Thornton)	21.48 minutes after flow is detected.
SW-6	Dry Naturalizing Detention Basin	Residential	White Oak Drive (off Tinker Rd)	21.15 minutes after flow is detected.

Automatic Sampler Setup

Program the time of concentration delay into the Model SS201 Stormwater sampler prior the field installation. The stormwater sampler will collect a discrete sample at this time after the sensor has detected water flowing. Refer to Appendix H of the QAPP for the Model SS201 manual for in-stream and in-pipe installation instructions. The automatic sampler should be installed shortly before the above conditions are met for sampling to minimize theft or vandalism.

SW-3 Sampler Setup

Stormwater samplers will be installed at the first catch basin in front of Pennichuck Square and at the manhole between Pennichuck Square and the Furniture Store, close to Pennichuck Brook. Follow the below guidelines to install the sampler:

1. Place road safety cone on either side of sampling location.
2. Put on reflective safety vest.
3. Remove storm grate or manhole cover.
4. Proceed to Appendix H of the QAPP for the Model SS201 manual for installation instructions.
5. Replace grate or manhole cover.

Sample Collection

The automatic sampler collects 1 400 ml sample. Collect the sample within 24 hours of the storm event. It is necessary to bring a cooler and ice to immediately chill the samples. First collect the inlet sample. The sample should be subdivided according to the following:

1. 100 ml in Phosphorus plastic container with Sulfuric Acid.
2. 200 ml in Total Suspended Solids container.
3. 100 ml in sampling duplicate (if necessary)

Procedure:

1. Open stormwater sampler and remove discrete sampling bottle. Transfer the sample to the appropriate containers as described above.
2. Fill all stormwater sample bottles to shoulder of bottle; do not fill and empty containers as some contain preservative (pre-preserved from laboratory); do not fill bottles to top of neck.
3. Close all lids tightly.
4. Record the required information for the collected sample onto the laboratory bottle label and the field data sheet.
5. Place laboratory bottle in cooler containing ice and keep cooler lid closed to maintain cool temperature and darkness.
6. Record any additional observations or deviations in the sampling procedures while collecting the sample.

Repeat for outlet sample collection.

SW-3 Sample Collection

The sample collection is consistent with general sample collection except that precautions need to be taken because this site is located in a parking lot with frequent traffic. Follow these additional steps for safety:

1. Place road safety cone on either side of sampling location.
2. Put on disposable/sterile gloves and reflective safety vest.
3. Remove storm grate or manhole cover.
4. Follow the Procedure above for Sample Collection.
5. Replace grate or manhole cover.

Repeat for each manhole/catch basin.

Proceed to Sample Delivery.

Sample Delivery

The following will take place to ensure proper sample delivery within the required holding time:

1. Fill out Chain of Custody (COC) form for Chemserve
2. Prepare cooler with samples for Chemserve for courier pick-up; sign COC when courier arrives and surrender coolers; keep copy of COC for final report.
3. Finally, note any QA/QC issues or modifications to the QAPP for discussion with QA/QC Officer and technical advisory team.

Field Supply and Equipment Checklist

Stormwater Sampling

Sampling Equipment

- ❑ Sample containers and labels (pre-preserved from laboratory)
- ❑ Model SS201 Stormwater Sampler
- ❑ Coolers
- ❑ Ice
- ❑ Field Data Sheet
- ❑ Sampling location map
- ❑ Distilled water
- ❑ Latex disposable gloves
- ❑ Crowbar to aid in grate removal
- ❑ Marker and pencil
- ❑ Chain of Custody
- ❑ QAPP

Safety Equipment

- ❑ Road safety cone
- ❑ Reflective safety vest

PENNICHUCK WATER WORKS

Field Data Sheet
Wet & Dry Weather Sampling

Field Data Sheet			
Site name and location			
Name of field team personnel			
Weather conditions			
Name of sample collected			
Sample identification			
Location of Sample			
Date of Collection		Time of Collection	
Site observations[1] - QA/QC Issues			

[1]OBSERVATIONS: (e.g. Appearance: *clear, murky, milky, foamy, sheen* Odor: *sewer, chemical, fishy* Floatable: *trash, pollen, algae*)

Field Data Sheet			
Site name and location			
Name of field team personnel			
Weather conditions			
Name of sample collected			
Sample identification			
Location of Sample			
Date of Collection		Time of Collection	
Site observations[1] - QA/QC Issues			

[1]OBSERVATIONS: (e.g. Appearance: *clear, murky, milky, foamy, sheen* Odor: *sewer, chemical, fishy* Floatable: *trash, pollen, algae*)

APPENDIX E

Dry Weather Sampling SOP

Dry Weather Sampling Standard Operating Procedure (SOP)

Sampling Process

The goal of the Pennichuck dry weather sampling is to collect some information that can be used in the model calibration and also to provide a baseline to which future changes in water quality can be assessed. Samples will be collected throughout Pennichuck Watershed based on previous sampling locations and at various points within the water column. Figure A6-2 and A6-3 in the QAPP show sampling locations.

This Standard Operating Procedure (SOP) will be used as a guide for proper procedures when making field observations, sampling and monitoring lake water, managing data, and completing quality control measures.

Samples will only be collected when the following conditions are met:

- Sampling must be done during dry weather.

Field Preparations

Field sampling activities will include boating to the sampling location, depth and secchi disk measurements, multi-meter monitoring, sample collection, sample preservation and transport. The following procedures were developed to ensure that data collection would remain consistent and accurate throughout the project.

Field Equipment Calibration

Calibration of field equipment necessary for collecting data will occur prior to the sampling event. All maintenance and repairs to the equipment will be completed at this time to prevent any impediment of the fieldwork. Procedures for calibrating the YSI 55 multi- meter and Hanna HI 98128 are included in the Appendix of the QAPP. Calibration of the multi-meter line, secchi disk line will include comparing the calibrated lines to a tape measure to make sure shrinkage or stretching has not occurred. If so, the calibrated line will be remarked or replaced.

Location Identification

Buoys are present at all in-pond sampling locations and will be used to accurately identify sampling location during each round of sampling. The tributary sampling locations are identified by the location of the stage gage.

Inspection / Acceptance Requirements for Supplies and Consumables

Field supplies and consumables will be inspected prior to use. Pennichuck will obtain sample bottles from the laboratory prepared with the appropriate preservations prior to the sampling event. Sample bottles will be needed for each sampling location, sample duplicate, plus extras. Sample bottles will be checked prior to use for cracks, leaks, and potential contamination. Should any bottle be deemed inadequate, it will be appropriately discarded. Back-up sample containers will be available during each sampling event. Distilled water will be obtained from a source of known quality and stored in appropriately labeled containers. Distilled water containers will be inspected in the same manner as the sample bottles and discarded if contamination occurs. The extended swing sampler and sampling buckets will be inspected for cleanliness and quality.

Equipment Decontamination Procedures

Surface Water Sampler

1. Wash and scrub thoroughly with laboratory detergent and hot water
2. Rinse thoroughly with hot tap water
3. Rinse with deionized water
4. Place equipment in proper storage container for transport
5. Rinse thoroughly with deionized water during field use

Observations and Field Records

Field Data Sheets will be completed on-site at the time of sampling and monitoring and will include the following information:

- Site name and location
- Names of field team personnel
- Sample date/time collection
- Weather conditions
- Site observations
- Station location
- Sample ID #
- QA/QC issues

Sampling/Monitoring Procedures

In-pond Sampling

Secchi Disk Reading

The secchi disk reading will be determined through the use of the calibrated secchi disk and the following steps:

1. Lower secchi disk until it disappears.
2. Lower the disk another one to two feet and slowly bring disk up until it is again visible.

3. Record this depth on the field sheet.
4. Repeat with field team partner and record reading.
5. Average of two readings is final reading.

YSI 55 Multi-Meter Monitoring

The YSI 55 Multi-Meter will be used at each in-pond monitoring location to measure Temperature, Dissolved Oxygen, at ½ meter intervals throughout the water column according to the following steps:

1. Remove multi-meter from case and rinse with distilled water.
2. Turn unit on by pressing POWER KEY.
3. Place multi-meter in water, at surface so that all sensors are submerged (approximately ¼ meter into water).
4. Select measurement parameter with MEAS KEY.
5. Allow readings to stabilize.
6. Record time.
7. Record Temperature and Dissolved Oxygen
8. Lower multi-meter to ½ meter depth and repeat above steps 4 through 7.
9. Continue to lower multi-meter at ½ meter intervals until bottom location is reached.
10. Take bottom reading at several inches above bottom sediment. Do not let multi-meter touch the bottom to avoid sediment being disturbed.
11. Rinse unit three times with distilled water.
12. Return unit to case.

Sample Collection

The following are instructions for collecting top and bottom samples.

1. Record Time on Chain of Custody.
2. Lower opened water sampler just below the surface.
3. Move sampler back and forth at specified depth to rinse.
4. Send messenger/weight down to activate mechanism for closure.
5. Open valve and fill bottles.
6. If there is not enough to fill all sample bottles, repeat steps 2 through 5.
7. Close all lids tightly.
8. Use the remaining water in the sampler and the Hanna HI 98128 to measure pH.
    a. Press and hold the On/Mode button until the display turns on.
    b. Place pH probe of meter into remaining water.
    c. Record pH when the stability symbol in the top left disappears.
    d. Verify that the temperature from the meter is similar to the temperature from the YSI 55 reading.
9. Record the required information for the collected sample onto the laboratory bottle label and the field data sheets.

10. Place laboratory bottles in cooler containing ice and keep cooler lid closed to maintain cool temperature and darkness.
11. Repeat Steps 3 through 9 lowering sampler to just above bottom and in the middle layer if one is identified.
12. Record any additional observations or deviations in the sampling procedures while collecting the sample.

Duplicate Sample Collection

One set of duplicate samples will be collected during each field event. Ideally, duplicate samples will come from the same sample aliquot and collected at one of the surface water locations according to the previously described method.

Tributary Samples

Sample Collection and Monitoring

The following are instructions for collecting tributary samples.

1. Record Time on Chain of Custody.
2. Measure DO and temperature and pH near water surface.
3. Fill bottle with no preservatives by placing them under the water.
4. Fill preserved bottles from other bottles.
5. At sites that are not reachable, take samples from bridge with Wildco Sampler.
6. Lower sampler into water.
7. Move sampler back and forth to rinse.
8. Uniformly move the sampler up and down to collect a composite sample of the vertical profile of the stream.
9. Send messenger/weight down to activate mechanism for closure.
10. Open valve and fill bottles.
11. If there is not enough to fill all sample bottles, repeat steps 2 through 5.
12. Close all lids tightly.
13. Record the required information for the collected sample onto the laboratory bottle label and the field data sheets.
14. Place laboratory bottles in cooler containing ice and keep cooler lid closed to maintain cool temperature and darkness.
15. Record any additional observations or deviations in the sampling procedures while collecting the sample.

Sample Delivery

The following will take place to ensure proper sample delivery within the required holding time:

1. Fill out Chain of Custody (COC) form for:
   - Chemserve (water chemistry except TOC)

- RI Analytical (Total Organic Carbon)

2. Prepare cooler with samples for Chemserve for courier pick-up; sign COC when courier arrives and surrender coolers; keep copy of COC for final report.
3. Prepare cooler for RI Analytical; sign COC when courier arrives and surrender coolers; keep copy of COC for final report.
4. Finally, note any QA/QC issues or modifications to the QAPP for discussion with QA/QC Officer and technical advisory team

Field Supply and Equipment Checklist

Lake & Tributary Sampling

Sampling Equipment

- ❑ Sample containers and labels (pre-preserved from laboratory)
- ❑ Coolers
- ❑ Ice
- ❑ Field Data Sheets
- ❑ Boat and motor and/or oars
- ❑ Sampling location map
- ❑ Distilled water
- ❑ Disposable gloves
- ❑ Watch
- ❑ Wildco sampler
- ❑ Secchi disk
- ❑ YSI 55 multi-meter
- ❑ Spare batteries
- ❑ Black marker and pencil
- ❑ Chain of Custody
- ❑ QAPP

Safety Equipment

- ❑ Floatation device/life preserver
- ❑ Cell phone

PENNICHUCK WATER WORKS

Field Data Sheet
Wet & Dry Weather Sampling

Field Data Sheet			
Site name and location			
Name of field team personnel			
Weather conditions			
Name of sample collected			
Sample identification			
Location of Sample			
Date of Collection		Time of Collection	
Site observations[1] - QA/QC Issues			

[1]OBSERVATIONS: (e.g. Appearance: *clear, murky, milky, foamy, sheen* Odor: *sewer, chemical, fishy* Floatable: *trash, pollen, algae*)

Field Data Sheet			
Site name and location			
Name of field team personnel			
Weather conditions			
Name of sample collected			
Sample identification			
Location of Sample			
Date of Collection		Time of Collection	
Site observations[1] - QA/QC Issues			

[1]OBSERVATIONS: (e.g. Appearance: *clear, murky, milky, foamy, sheen* Odor: *sewer, chemical, fishy* Floatable: *trash, pollen, algae*)

APPENDIX F1

VTPSUHM Methodology

Travel Time Calculations: Virginia Tech/ Penn State Urban Hydrology Model (VT/PSUHM) Created by Dr. David F. Kibler and Clayton C. Hodges

The SCS segmental approach was used to calculate travel times for the Pennichuck stormwater QAPP due to the combination of different flow paths that contribute stormwater to the sample locations. The drainage areas that contribute to each sample location are based on the urban drainage network since the goal of the sampling program is to collect stormwater associated with urban runoff, which is likely to contribute the greatest concentration of pollutants during first flush conditions. The SCS segmental approach is discussed in detail below, as adapted from the VT/PSUHM manual.

SCS Segmental Approach

The segmental approach to estimating travel time has been recommended by the faculty at Penn State University, based upon their dye tracer studies and other rainfall/runoff analysis. The SCS also has recommended this approach and it appears as Chapter 3 in the 1986 publication of TR-55. The user can refer to chapter 3 of TR-55 for specific details of the method. To run the segmental option in this module, the user is asked to enter a descriptive name (for display purposes only), the number of segments in the flow path and a classification for each segment in the path as either overland (O), concentrated (C) or channel (H). In this module, channel flow can be either open channel or pipe full flow (the user will input flow area and wetted perimeter).

For each segment the user must enter the required data for solution of appropriate equation. To solve the overland flow equation, the user must enter segment length, slope, roughness coefficient, and the 2-yr, 24-hr rainfall for the region. A screen table of roughness coefficients is provided for user convenience. This table is identical to the table provided in chapter 3 of TR-55 (1986). The rainfall information must be obtained from rainfall charts or tables. In Pennsylvania, the PennDOT PDT-IDF charts are recommended (Aron et al., 1986) and these have been incorporated in the Rainfall Module of VT/PSUHM. To solve the concentrated flow equation, the user must identify the flow segment as paved (P) or unpaved (U). Then the segment length and slope must be entered. These are the only data that are needed. The module is reading Figure 3-1 of TR-55 (1986) for velocity and then computing a time based on length. To solve the channel flow equation (Manning's), the user must enter flow area, wetted perimeter, channel length, roughness coefficient and channel slope.

Once data have been entered for each segment in the flow path, the module will provide an output screen showing the segmental flow times and the total travel time through all segments. Note that this module does have a file save option. Hitting the Done button returns the user to the main menu screen. This segmental option allows the entry of as many segments in a flow path as desired by the user. It is possible that a channel flow segment could exit to a concentrated flow segment. It is actually possible (not probable) that a channel segment or concentrated segment could discharge to a overland (sheet) flow segment. In general, a flow path will start with sheet flow and develop into concentrated flow, and finally develop into channel flow. Refer to chapter 3 of TR-55 for a more complete treatment of this method.

References

Aron, G., D. J. Wall, E. L. White, D. N. Dunn, D. M. Kotz, 1986. Field Manual of Pennsylvania Department of Transportation Storm Intensity- Duration-Frequency Charts. Department of Civil Engineering and Institute for Research on Land and Water Resources, The Pennsylvania State University, University Park, PA, 9 pp.

Morgali, J. R., R. K. Linsley, 1965. Computer Simulation of Overland Flow. Journal Hydraulics Division ASCE 91(81), May 1965.

Soil Conservation Service, 1975. Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Engineering Division, Washington, DC, 51 pp.

Soil Conservation Service, 1986. Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Engineering Division, Washington, DC, 156 pp.

APPENDIX F2

Travel Time Calculations

SCS Segmental Travel Time

Summary for Infiltration - LID

Segment 1: Concentrated Flow
L = 15 ft, S = .01 ft/ft, Paved surface
Travel Time = .1 minutes

Segment 2: Concentrated Flow
L = 75 ft, S = .01 ft/ft, Paved surface
Travel Time = .6 minutes

Total Travel Time = 0.74 Minutes

SCS Segmental Travel Time

Summary for Grass Detention Pond

Segment 1: Overland Flow
L = 100 ft, S = .01 ft/ft, n = .4, P(2yr/24hr) = 2.95 in
Travel Time = 29.5 minutes

Segment 2: Concentrated Flow
L = 85 ft, S = .01 ft/ft, Paved surface
Travel Time = .7 minutes

Total Travel Time = 30.21 Minutes

SCS Segmental Travel Time

Summary for Wet Pond

Segment 1: Overland Flow
L = 100 ft, S = .01 ft/ft, n = .4, P(2yr/24hr) = 2.95 in
Travel Time = 29.5 minutes

Segment 2: Concentrated Flow
L = 80 ft, S = .01 ft/ft, Paved surface
Travel Time = .7 minutes

Total Travel Time = 30.17 Minutes

SCS Segmental Travel Time

Summary for Detention Pond

Segment 1: Overland Flow
L = 65 ft, S = .01 ft/ft, n = .4, P(2yr/24hr) = 2.95 in
Travel Time = 20.9 minutes

Segment 2: Concentrated Flow
L = 70 ft, S = .01 ft/ft, Paved surface
Travel Time = .6 minutes

Total Travel Time = 21.48 Minutes

SCS Segmental Travel Time

Summary for Dry Naturalized

Segment 1: Overland Flow
L = 65 ft, S = .01 ft/ft, n = .4, P(2yr/24hr) = 2.95 in
Travel Time = 20.9 minutes

Segment 2: Concentrated Flow
L = 30 ft, S = .01 ft/ft, Paved surface
Travel Time = .2 minutes

Total Travel Time = 21.15 Minutes

SCS Segmental Travel Time

Summary for Forebay/Swale

Segment 1: Overland Flow
L = 100 ft, S = .01 ft/ft, n = .011, P(2yr/24hr) = 2.95 in
Travel Time = 1.7 minutes

Segment 2: Concentrated Flow
L = 1600 ft, S = .01 ft/ft, Paved surface
Travel Time = 13.1 minutes

Total Travel Time = 14.78 Minutes

APPENDIX G1

SS201 Sampler Manual

Global Water

Instrumentation, Inc.

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T: 800-876-1172
Int'l: (916) 638-3429, F: (916) 638-3270

Stormwater Sampler: SS201

5/23/02

Global Water
800-876-1172 • globalw.com

Congratulations on your purchase of the Global Water SS201 Stormwater Sampler. This instrument has been quality tested and approved for providing accurate and reliable measurements. We are confident that you will find the SS201 to be a valuable asset for your application. Should you require assistance, our technical staff will be happy to help.

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I. SS201 Checklist

a. Stormwater Sampler

b. 12V Battery (Inside Enclosure)

c. Battery Charger

d. SS201 Manual

e. RG333 Auto-Drain Rain Gauge

f. RG333 Manual

II. Inspection

a. Your SS201 unit was carefully inspected and certified by our Quality Assurance Team before shipping. If any damage has occurred during shipping, please notify Global Water Instrumentation, Inc. and file a claim with the carrier involved.

   Use the checklist to ensure that you have received everything needed to operate the SS201.

III. Description

a. The Global Stormwater Sampler, SS201, is designed specifically to meet the sampling requirements of the Stormwater program. The Global Sampler takes a "first flush" sample in one bottle and a “time weighted” composite sample in the second bottle, to meet the guidelines. It is actually two samplers in one: it consists of two intake tubes, two sampling pumps and two bottles, which eliminates any possibility of cross contamination between the first flush and the composite sample. The Global Stormwater Sampler is easily set up and installed in any stormwater channel to take and store physical water samples throughout the storm event.

b. The Global Stormwater Sampler consists of a rugged, rainproof lockable carrying enclosure. Inside the enclosure are two 4000 ml sample bottles for first flush and composite samples, two peristaltic sampling pumps, a control panel, a water sensor, a rain sensor, and a rechargeable battery. A rain gauge and a battery charger are also provided.

IV. Installing the Stormwater Sampler

SAMPLING LOCATION

a. To meet specific permitting requirements, sampling locations may need to be established and certified by a licensed Professional refer to your permitting requirements prior to establishing a sampling program. An appropriate sampling location will most likely be:
   - Close to a storm water discharge channel or stream
   - Situated so the rain gauge is away from trees and buildings
   - Removed from public areas

SAMPLING UNIT

b. The sampler should be placed upright (it will not work if placed on its back or side) within 15 feet of the rain sensor (see installation instructions below).

c. Open the sampler and remove the battery charger from the unit. . Store the charger for later use.

d. To secure the sample bottles:
   1) Screw the bottle caps/float switches onto the sample bottles
   2) Place bottles into the sampler enclosure
   3) Insert end of peristaltic pump hose into the hole in each bottle cap
   4) Plug the float switch leads into the control panel. Each pump has a jack associated with it. The bottle switch needs to be plugged into the jack associated with its respective pump. (Located under control panel enclosure).

e. The sampling unit can be secured from vandalism and strong winds by one of the following methods:
   - Mount unit on post and lock closed
   - Lock closed and chain handles to a solid structure (such as a tree, post, or building)
   - Enclose and lock unit in a steel electrical box

f. Avoid drilling holes in the enclosure if possible. If holes must be drilled in the enclosure avoid drilling through the control panel enclosure. Any holes drilled through the enclosure must be sealed with some type of silicone glue to prevent water from entering the case and causing an equipment failure.

g. The unit is water resistant, not water proof. The unit must be located well above the expected water level to continue to provide reliable service.

V. Installing the Rain Gauge

a. Please refer to the RG333 Auto-drain Rain Gauge for instructions.

VI. Installing the Rain Sensor

a. The rain sensor can be set up to trigger a sample in one of two ways. Either based on rainfall inside the rain gauge or based on a rise in water level in a storm drain. To trigger the sampler based on water level skip to the section on installing the pickup hose.

b. The rain sensor is used to trigger a sample for specific amounts of rainfall accumulation. Based on your application's requirements, insert the tip of the rain sensor into the rain gauge at a specified rainfall accumulation (0.1 to 0.6, 1.0, or 2.0 inches). Securely hook the rain sensor's cable into the groove in the cylinder and place a tie wrap (provided on the cable) outside the groove to secure the installation. Insert the rain sensor's plug into the "Sensor" socket on the control panel.

VII. Installing the Pickup Hose

a. The pickup hose should be installed in a storm water discharge channel or stream that is appropriate for your sampling program. The pickup hose can be installed in the following manner:

Securely insert a piece of mounting material into the center of the channel.

1) Securely insert a piece of rebar or similar mounting material into the center of the storm water discharge channel or stream. The material should extend from the bottom of the channel at a distance appropriate for the pickup hose installation.

Dry Channel

b. In a dry channel, fasten the rain sensor and the end of the pickup hose onto the mounting material using tie wraps, electrical tape, or hose clamps. Ideally, the pickup strainer should be placed at 1/2 the depth of flow during a storm event. The rain sensor should be tied just above the debris strainer, in order to trigger a sample after the sample intake is submerged. The rain sensor and pickup hose should be situated to avoid contact with the channel bottom.

In a dry channel, the rain sensor should be tied just above the debris strainer.

Stream

c. In a stream, fasten the end of the pickup hose onto the mounting material using tie wraps or hose clamps. The pickup strainer should be submerged under water and should be situated to avoid contact with the channel bottom.

In a stream, the pickup strainer should be submerged under water.

VIII. Using the Stormwater Sampler

a. Verify that the sampling unit, rain gauge, rain sensors, and sampling pickup hose are installed correctly (see previous sections). The Global Water SS201 Stormwater Sampler will function only if the battery plug is securely fastened into the battery socket on the control panel, the float sensor plugs are inserted into their sockets, and the rain sensor is plugged into its socket.

b. Set the composite sample Interval and Size knobs to the approximate values desired. For a precise sample size see appendix A.

c. Verify the rain sensor contacts are dry. Turn the sampling unit ON (switch is on the control panel) and verify that the sampler is operating. Press the momentary switches to test each of the pumps. The momentary switches can also be used to take manual samples. If the pump turns slowly, the battery voltage should be checked and recharged if necessary, see the Maintenance section. If the momentary switches do not cause the pump to run, verify that each bottle switch is connected to the control panel and that the battery is charged. If the unit still does not sample, refer to the Trouble Shooting section. The unit must be ON to take automatic samples.

d. Verify the automatic sampling works by placing the rain sensor in about an inch of ionized water. NOTE: The sampler will not take a sample if the water is deionized. If this is an issue, a small amount of salt or dirt placed inside the rain gauge will cause the rain sensor to trigger the sampler correctly.

e. The sampler takes two types of samples. The first flush/discrete sample bottle will be filled during the first event that triggers the sampler. The composite sample bottle fills according to the sample specifications set by the user. It will continue to sample as long as the rain sensor is immersed in water and the float switch has not been activated. The float switch in the bottle cap will turn the pump off before the sample bottle overflows. After a storm, remove the sample bottle or transfer the sample to a small bottle for lab or turbidity meter analysis. Then, install an empty, clean bottle.

IX. Using the Rain Gauge

a. Please read the RG333 Rain Gauge Manual for rain gauge instructions.

Daily Log

b. Whenever possible, take rainfall readings at the same time each day. Record the readings on the daily log, appendix B. Use the date on which the readings are taken even though much or all of the rain may have fallen the preceding day, after the daily reading was taken for the previous day. Enter the reading in hundredths of an inch (.01, .31, 1.01, 3.01). If the rainfall is less than 0.1 enter "T" for trace in the daily precipitation log.

X. Specifications

Sample Size:	First Flush: 4000 ml Composite: Set by user (4000 ml composite sample maximum)
Operating Temperature:	0° to +70°C
Size of unit:	9"L X 17"W X 22"H
Weight:	22lb (Shipping Weight 24lb)
Materials:	
Enclosure:	Expanded UV protected PVC
Bottles:	4000 ml Polyethylene
Sample Tubing:	15' nylon reinforced 1/4" ID polyethylene flexible tubing sections with intake strainers
Sample Pumps:	
Flow Rate:	1000 ml per minute at 4 ft. head
Type:	Peristaltic
Maximum Lift:	22'
Water Level Sensor:	Solid State with a 15' cable.
Battery:	Rechargeable 5 AH Gel Cell
Battery Life:	The battery will power the sampler for a minimum of four months including five 24-hr. storm events before recharging is required.

XI. Maintenance

Sampler

a. The Global Water SS201 Stormwater Sampler requires minimal maintenance. The sampler enclosure is rainproof and rugged. Avoid exposure to extremely rough usage. Routinely wipe the carrying case and control panel face, rinse the pickup hose and debris strainer, and wash the sample bottle with mild soap and warm water. Additional plastic and glass sample bottles, norprene tubing for the sampler pump, bottle caps/float switches, removable debris strainers, sensors, and pickup hose can be purchased from Global Water (see Appendix C section).

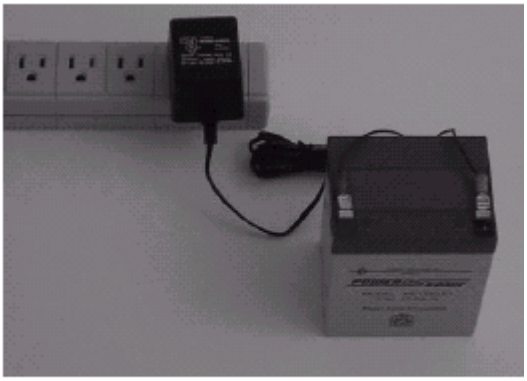
Rain Gauge

b. Please see the RG333 Auto-Drain Rain Gauge manual for more information.

Battery

c. The battery will last without requiring recharging through several storm events. If the pump grinds slowly, this is an indication that the battery requires recharging. We recommend fully recharging batteries approximately once per month. In addition, the battery should be recharged before any extended use. NOTE: The battery life will last longer if recharged before it drains below 10.5 volts.

d. To recharge the battery, unfasten it from the control panel, slide it out of the carrying case, and unhook the cord from the battery terminals. Then, fasten the battery charger's disconnects onto the battery terminals and plug the charger into a wall socket. Full recharge will take about 12 hours. Additional batteries and battery chargers are available from Global Water (see Appendix C section).



To recharge the battery, fasten the charger's disconnects onto the battery terminals and plug the charger into a wall socket.

XII. Trouble Shooting

Issue: Pumps run all the time

a. Verify the rain sensor probes are not shorted together. Clean the probes with a wire brush. Unplug the rain sensor. The pumps should both stop.
b. Verify the float switches are working correctly. Lift the float off the end of the switch. The pump should stop. Test both pumps.

Issue: One of the pumps does not work

c. Swap float switches. If the other pump stops working the float switch is bad and needs to be replaced.

Other issues

d. Call us for tech support: 800-876-1172 or 916-638-3429 (many problems can be solved over the phone). Fax: 916-638-3270 or Email: **globalw@globalw.com.**

   Be prepared to describe the problem you are experiencing including specific details of the application and installation and any additional pertinent information.

e. In the event that the equipment needs to be returned to the factory for any reason, please call to obtain an RMA# (Return Material Authorization). Do not return items without an RMA# on the outside of the package.

   Include a written statement describing the problems.

   Send the package with shipping prepaid to our factory address. Insure your shipment, as the warranty does not cover damage incurred during transit.

f. When calling for tech support, please have the following information ready;

   1. Model #.
   2. Unit serial number.

3. P.O.# the equipment was purchased on.
4. Our sales number or the invoice number.
5. Repair instructions and/or specific problems relating to the product.

XIII. Warranty

a. Global Water Instrumentation, Inc. warrants that its products are free from defects in material and workmanship under normal use and service for a period of one year from date of shipment from factory. Global Water's obligations under this warranty are limited to, at Global Water's option: (I) replacing or (II) repairing; any products determined to be defective. In no case shall Global Water's liability exceed the products original purchase price. This warranty does not apply to any equipment that has been repaired or altered, except by Global Water Instrumentation, Inc., or which has been subject to misuse, negligence or accident. It is expressly agreed that this warranty will be in lieu of all warranties of fitness and in lieu of the warranty of merchantability.

b. The warranty begins on the date of your invoice.

XIV. Appendix A: Automatic Sampler Calibration

a. The composite sample size is approximate. This means that the sample size may vary with distance from the sampler. If precise sample sizes are need it will be necessary to manually calibrate to the installation.
b. To manually calibrate, you will need a graduated cylinder that exceeds your intended sample size.
c. Follow these steps to calibrate:
    1. Install the sampler in its intended location.
    2. Remove the sample bottle.
    3. Adjust the sample size to roughly the size you intend to take.
    4. Place the graduated cylinder under the output of the pump.
    5. Turn on the sampler, press and hold and press the red pushbutton.
    6. When the sampler is finished pumping, check the amount sampled in the graduated cylinder.
    7. If the sample size is incorrect:
       Empty the cylinder and slightly adjust the sample size clockwise for a larger sample and counter-clockwise for a smaller sample. Then repeat steps 4 through 6.
    8. If the sample size is correct:
       Empty the cylinder and replace the sample bottle. Be sure to re-connect the lead from the bottle cap into its socket, and make sure the output of the pump is going into the bottle.

These steps will need to be repeated for every individual installation.

XV. Appendix B: Daily Rainfall Log Sheet

1. Try to record precipitation each day
2. Record precipitation to the nearest 1/100th of an inch (.01,.31,1.31,etc.)
3. If precipitation is less than .01, record "T" for trace.
4. Use the remarks column to list any unusual weather.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Remarks
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													
31													
Total													

XVI. Appendix C: Accessories

Part Description	Part Number	Unit
12V 5Ah Battery	00-010	Each
Battery Charger	FE0400	Each
1 Gal Plastic Sample Bottle	00-418	Each
Bottle Cap/Float Switch	CB0200	Each
Rain Gauge	CA0800	Each
Pickup Hose	00-546	Feet
Pickup Strainer	CA0300	Each
Pump tubing	00-744	Feet
Rain Sensor	CB0400	Each

APPENDIX G2

WL15 Level Logger Manual

Global Water
Instrumentation, Inc.

WL15

Water Level Logger User's Guide

6/5/2002

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Requirements

- Windows 95, 98, ME, NT, 2000 or XP*
- 486DX 66MHz, 16MB RAM (Windows 95 base machine; later operating systems may require higher specifications)
- Available COM port

Contact Information

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Web: www.globalw.com

Terminology

In order to better understand this product manual, please be aware of the following terminology and formatting usage.

Bolded terms (i.e. **bold**) indicate either a keyboard key, a word or icon that appears on your computer monitor screen or a phrase to be emphasized. Context will dictate which is indicated.

Since it is assumed that users of this manual are familiar with mouse usage, many mouse operations are implied. The term "click" or "clicking" means to press and release the left mouse button. Similarly, "double-click" means to press and release the left mouse button twice in quick succession. For example, the phrase "Click the **start** button" should be interpreted as "Move the mouse pointer to the task bar and click the **start** button." If any other mouse button is used in an operation, it will be specified in the documentation.

The term "select" means to move the mouse pointer over the indicated target. For example the phrase "Select **Toolbars** from the **View** menu" means to move the mouse pointer over **Toolbars** after the **View** menu has been displayed. "Select" is normally used when the mouseover action will cause additional menus to display.

The → symbol is used with submenu operations where the user should click the first and last items in the string separated by →. For example, the phrase "Click on **File** → **New** → **Folder**" means click on **File**, select **New** and click on **Folder**.
When the documentation directs you to exit a program or window, you can generally do so by clicking the **x** graphic in the upper right-hand corner or by clicking **File** → **Exit**.

*Windows® 95, 98, ME, NT, 2000 & XP are trademarks of the Microsoft Corporation

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COMMUNICATION COMMANDS FOR WINDOWS DATALOGGER *40*

Introduction 1

The WL15 Water Level Logger

Congratulations on your purchase of the Global Water WL15 Water Level Logger. This instrument has been quality tested and approved to provide accurate and reliable water level (water pressure) measurements. We are confident you will find the WL15 to be a valuable asset for your applications. Should you require assistance, our technical staff will be happy to help.

The WL15 provides a datalogger with a submersible pressure transducer for remote monitoring and recording of water level, flow or pressure data. This highly reliable and accurate water logger records 24,400 readings and is programmable from one reading per second to one reading per day. Ranges of 0-3', 0-15', 0-30', 0-60', 0-120' and 0-250' are available. A 25' cable is standard, and optional cable lengths are available up to 1000'.

The WL15's datalogger is housed in a weather-resistant cylindrical enclosure that slips inside a 2-inch pipe. The logger is easily adapted with standard hardware for well head mounting or other installations. The WL15 includes Windows-based software, allowing easy upload of data to standard spreadsheet programs on a PC computer.

The WL15's level sensor electronics are fully encapsulated with marine-grade epoxy, providing superior moisture protection over O-ring seals. During this process, the vent tube is sealed directly to the sensing element, preventing any moisture from damaging the sensor's electronic components.

The level sensor uses a unique silicon diaphragm to interface between the water and the sensing element. This silicon diaphragm is highly flexible and touches the sensing element, producing a sensor with exceptional linearity and very low hysteresis. The pressure transducer utilizes a stainless steel micro-screen cap to protect the sensing element. This protective cap has hundreds of openings, making fouling the sensor with silt, mud or sludge virtually impossible.

Features

Data
- Windows based Global Logger* software
- Tabular display/printout
- Data in standard spreadsheet format
- Communication cable included (RS232C)

Logger
- Weather resistant enclosure
- Fits inside 2" pipe
- Records 24,400 readings
- 12 bit or 1/4,000 resolution
- Battery powered

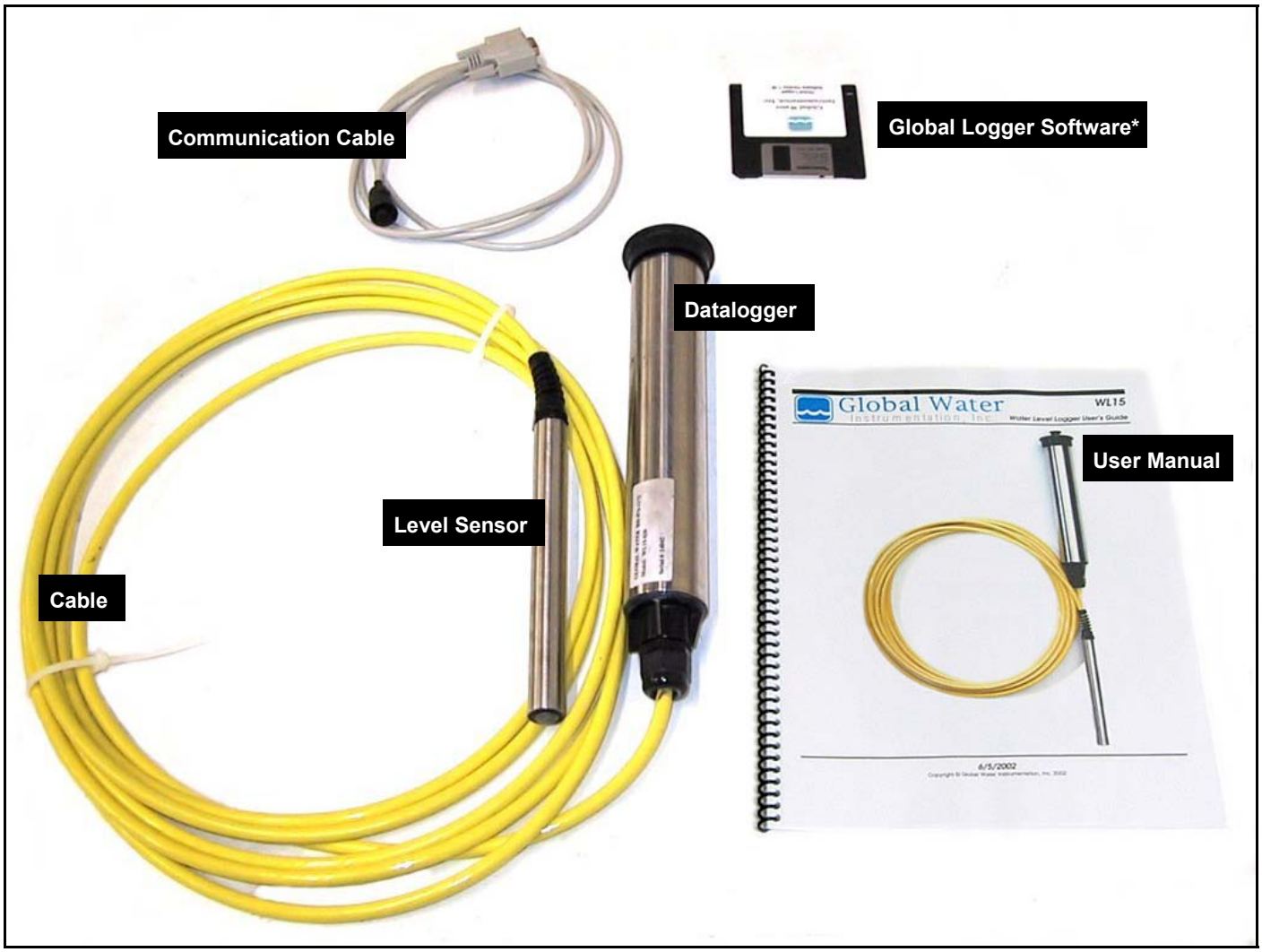
Cable
- Marine grade, heavy urethane jacket
- Barometric pressure vent
- Lengths up to 1000'

Sensor
- Fully encapsulated submersible pressure transducer
- Amplified and temperature compensated
- High accuracy
- 3/4" diameter wet-wet transducer (no vent moisture problems)

*Copyright © Global Water Instrumentation, Inc. 2001

Checklist

Your WL15 was carefully inspected and certified by our Quality Assurance Team before shipping. If any damage has occurred during shipping, please notify Global Water Instrumentation, Inc. and file a claim with the carrier involved. Use the checklist to ensure that you have received everything needed to operate the WL15. Your sensor has been inscribed with the sensor range for easy identification.

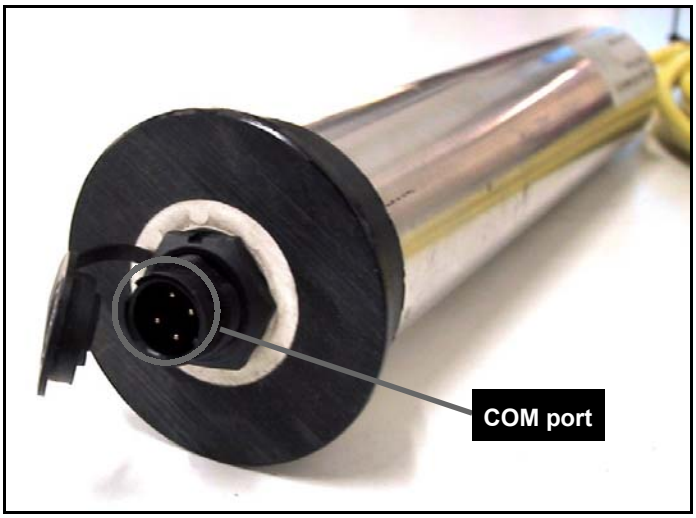


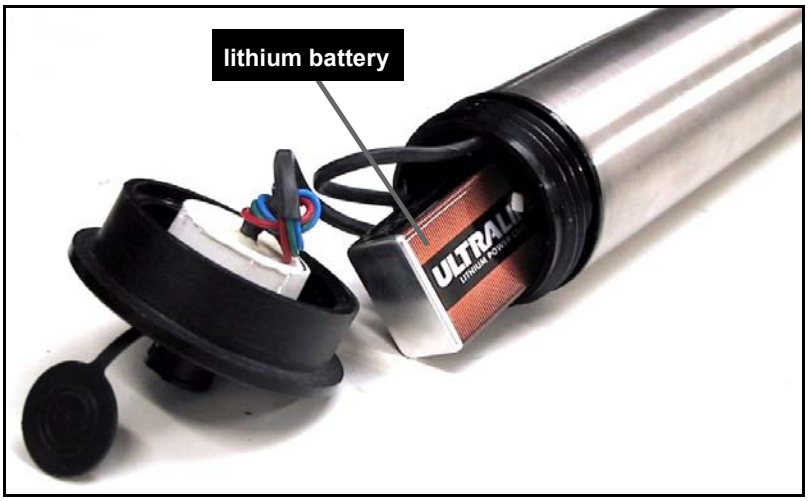
- WL15 (Datalogger, Level Sensor and Cable)
- User Manual
- Communication Cable (RS232C COM Cable)
- Global Logger Software (3 1/2" Floppy Diskette)

*Copyright © Global Water Instrumentation, Inc. 2001

Getting to Know the WL15

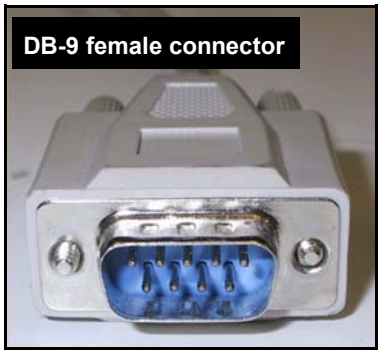
The COM port can connect to a PC serial port using the included Communication Cable.

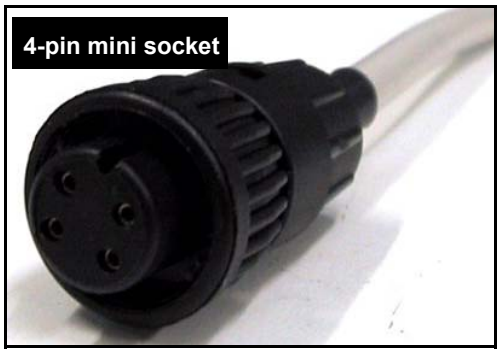




Unscrew logger cap to access lithium battery.

The Communication Cable has two different connectors. Connect the DB-9 female connector to your PC and the 4-pin mini socket* to your Datalogger.





*See **Appendix C: Cable Configuration**, page 39

The water level sensor is located inside the sensor housing, near the mesh screen.

Setup

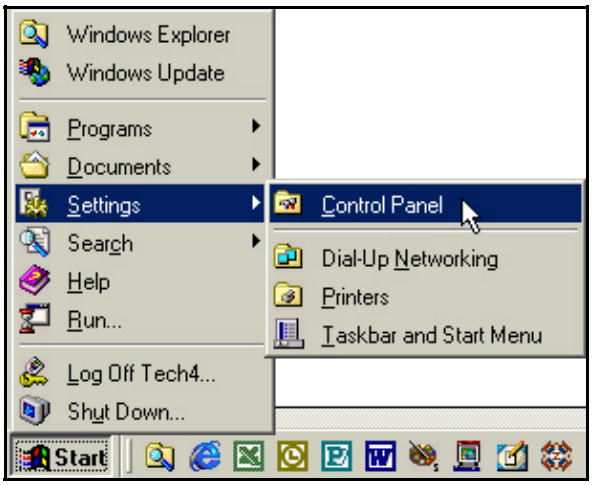
2

Installing the WL15

System Time Check

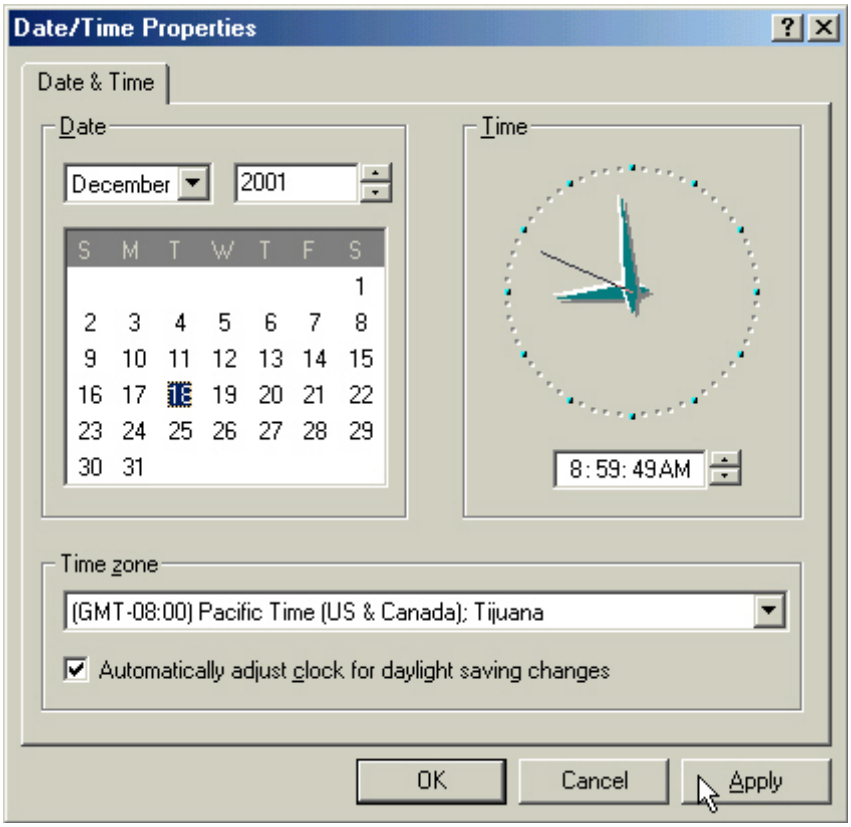
Before you install the software, check the accuracy of the time and date on your computer. The WL15 will be programmed with this information.

To verify your system time in Windows, click **Start → Settings → Control Panel** from the task bar.



Double-click the **Date/Time** icon.

Verify that your system is set to the correct time. If not, make the necessary changes and click the **Apply** button followed by the **OK** button. Exit the control panel.



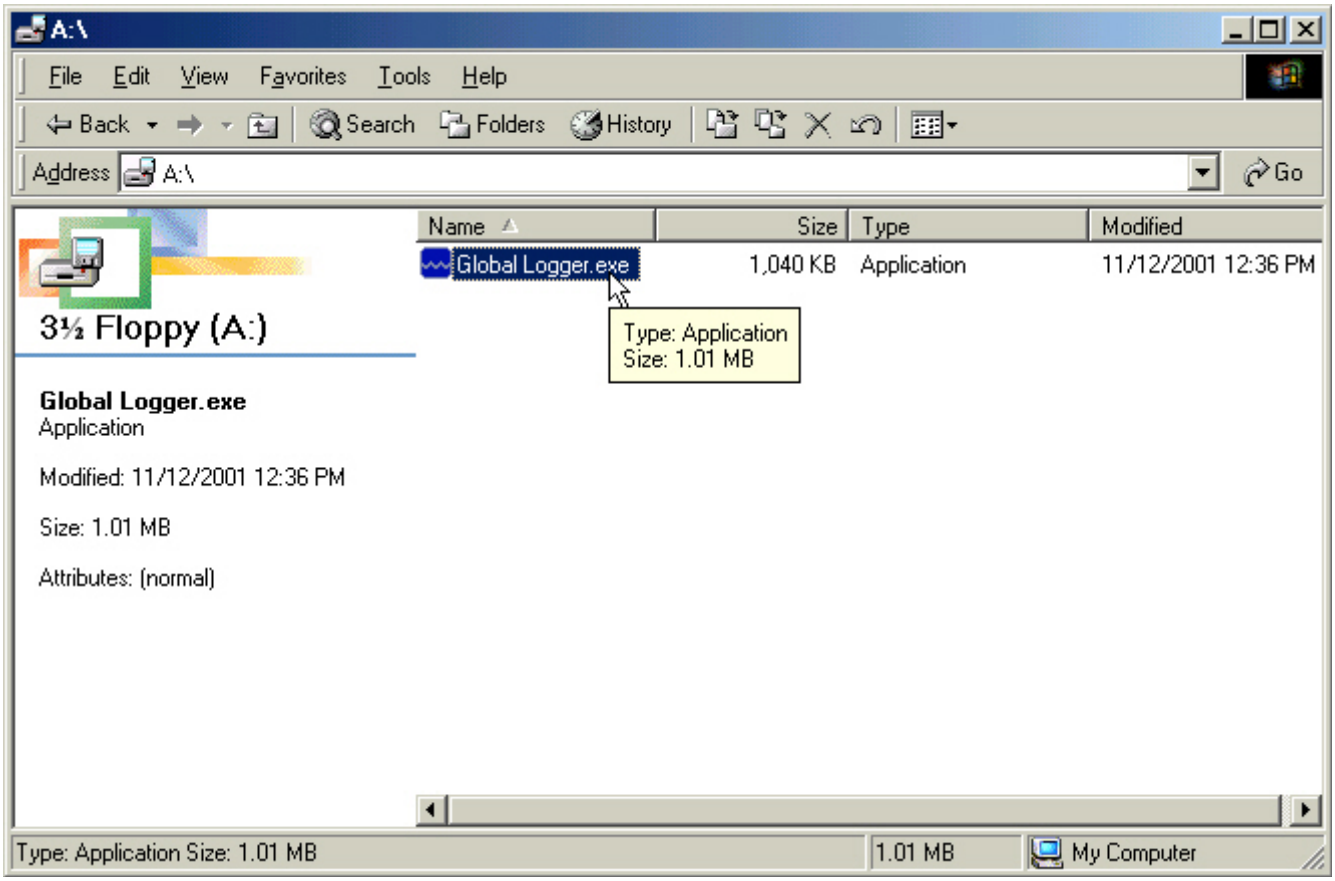
Global Logger Software Installation

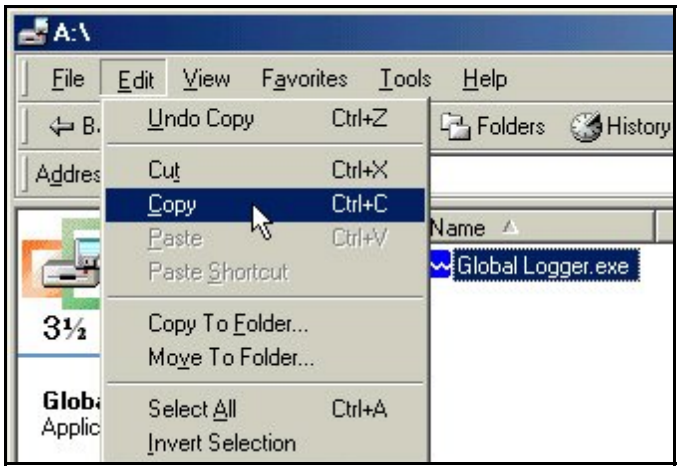
Insert the 3 1/2" floppy diskette labeled "Global Logger Software Version x.xx" (where x.xx is a version number such as 1.36) into your computer's floppy disk drive. Normally, the floppy will be the computer's "A" drive.

Double-click the **My Computer** icon on your desktop.

Double-click the floppy icon (normally listed as **3 ½ floppy (A:)**).

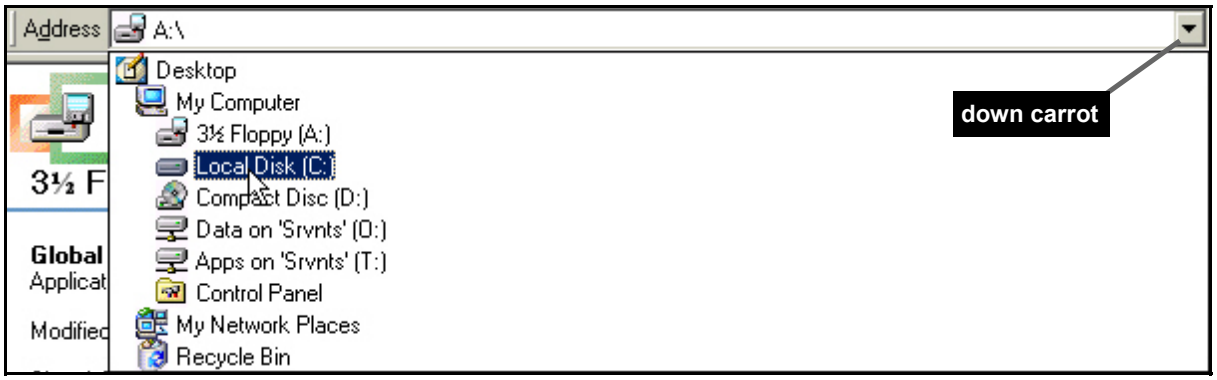
Click on the file **Global Logger.exe**.

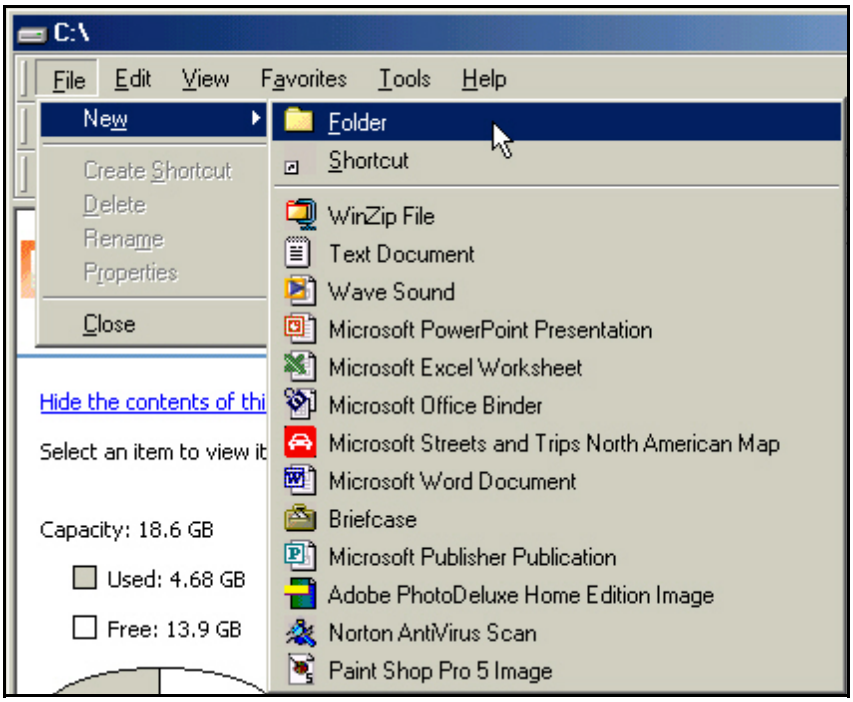




Click **Edit → Copy** from the menu bar.

Save the file to a directory of your choosing. Note, it should be a location you will easily remember. To save to the directory **Global Logger** located on your main "C" hard drive (although "C" is normally the main system drive, the designation can vary from system to system), start by clicking the down carrot of the address field. Click on the **Local Disk (C:)** icon or appropriate main system drive designation.

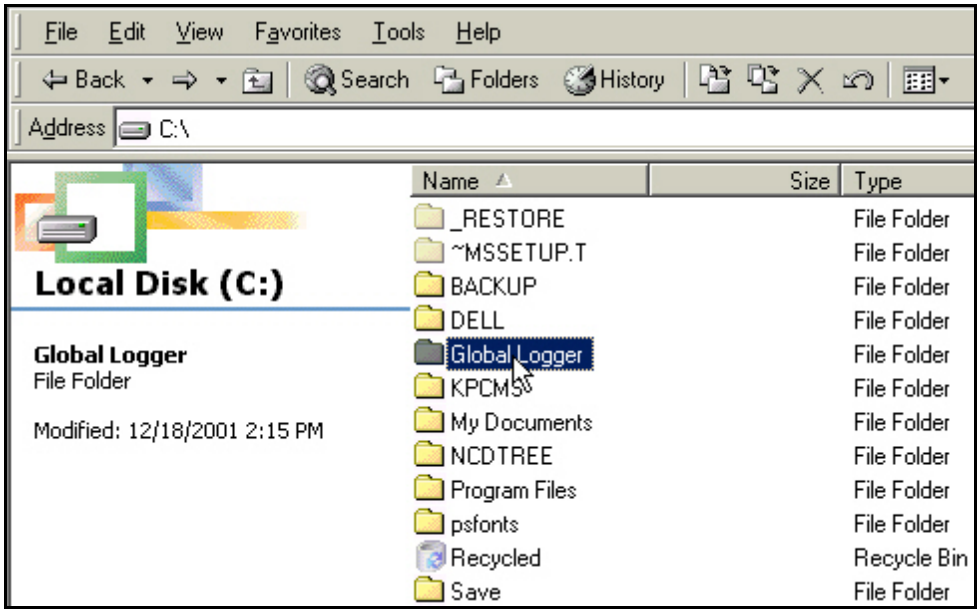


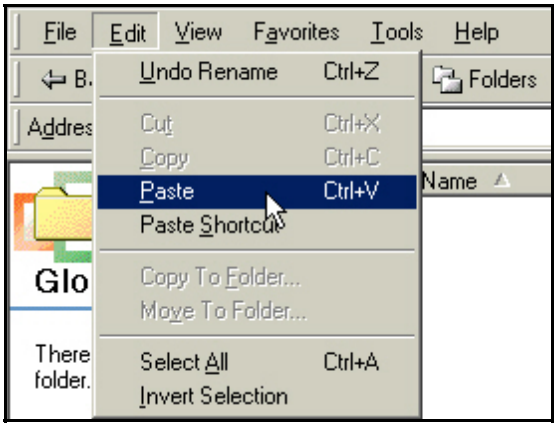


If the directory **Global Logger** is not listed, click **File → New → Folder** from the menu bar.

The directory **New Folder** should now be created and automatically selected for typeover. Type **Global Logger** and press the **enter** key.

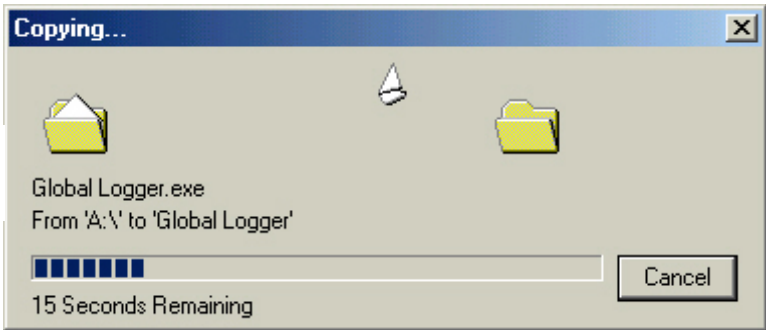
Double-click on the new **Global Logger** directory.



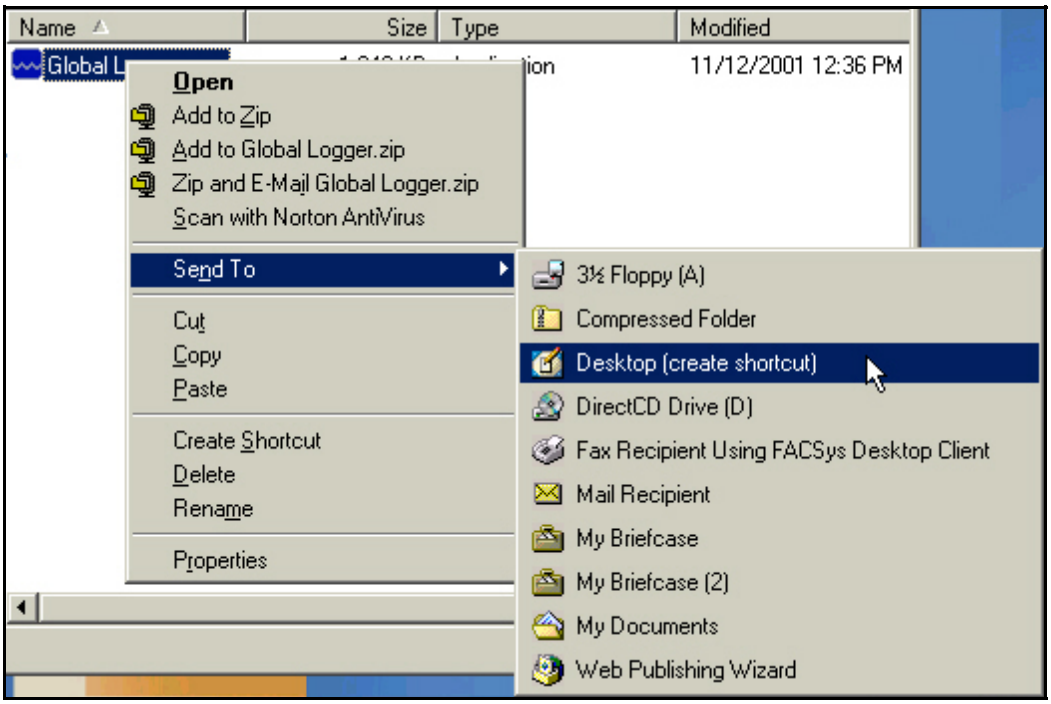


Click **Edit → Paste** from the menu bar.

A **Copying…** dialog box should now display. Wait for the copy process to complete.



To create a desktop shortcut, right-click the **Global Logger.exe** file you previously saved, select **Send To** and click on **Desktop (create shortcut)**.



You can now access your Global Logger* software directly from the desktop.

Hardware Installation

General Installation Tips

- The WL15 has many applications and therefore many installation options. The WL15's pressure sensor is fully submersible and may be suspended by its waterproof cables in the water to be monitored.
- **The data logger is not waterproof**. It is water-resistant. This means that condensation, which can build up inside the enclosure during humid conditions, should not affect the performance of the WL15. However, if the data logger is submerged in water, it will corrode the electronics and cause it to stop working properly. Please ensure that the data logger will be clear from flooding and out of direct rainfall.
- **Do not install the WL15 in applications that contain solvents**. Over time, many solvents can deteriorate the cable and the sensing element.
- The accuracy of the sensor readings can be affected by such adverse conditions as overpressure, lightening strikes, improper care/handling, and physical damage or abuse.

- The WL15's cable contains a vent tube that allows for barometric pressure compensation. **Do not allow the vent tube to become kinked or obstructed as this may cause erroneous readings**.
- Install your WL15 so that it is easily accessible for calibration purposes. You may need to remove and reinstall it in the future, so plan ahead!
- The pressure sensor will not function correctly if buried by mud, silt, leaves, or other debris. Install the sensor in a way that avoids these conditions.

Groundwater Installation

- For best results suspend the pressure sensor in a 2" monitoring well near the well screen. The sensor may be installed in well diameters 1" and up.
- For a 2" diameter pipe (or larger), the sensor can be inserted directly. Slowly lower the sensor into the well. Warning: **Do not allow the sensor to "freefall" down the well, this may cause damage to the sensor**. The top of the data logger will rest on the top of the well pipe. A slip cap or a locking well cap can conceal the WL15. The cable length of the WL15 should be sized so the sensor will be positioned below the lowest expected water level, which is not necessarily the bottom of the well. The correct cable length is measured from the top of the data logger to the bottom of the sensor. The sensor's measuring range should be slightly larger than the expected total amount of change in water level.
- To shorten the cable in a 2" diameter or larger well, coil it around a 1" diameter stick or pipe and secure the cable at both ends with tie wraps or tape. Warning: **Do not kink the cable; this may damage the internal vent tube**.
- The WL15 can be adapted to larger or smaller well casings by using standard PVC pipe reducers and fittings or Global Water's Inside Well Option.
- As factory programmed, the WL15 records depth of water above the sensor. If you want to use your WL15 to record depth to water readings, follow the worksheet **Calibrating Level Sensors for Depth to Water Readings***.

Surface Water Installation

- The sensor may be submerged at the monitoring point and hung from its cable. It is recommended to protect the sensor and datalogger inside a 4" PVC drainpipe that will act as a protective stilling well. PVC schedule 40, or ABS sewer drainpipe is recommended. PVC schedule 40 electrical conduit has UV protectors and pre-formed "sweeps" or bends that enable it to conform to the contours of a riverbank. The level sensor will slide down through 45° or 90° sweeps. The pipe may be buried in the riverbank, secured with rocks, or fastened to the bank with large staples made by bending pieces of concrete reinforcing steel in half and driving them into the bank. Put a cap on the bottom end of the pipe to allow easy water flow past the sensors. Drop the sensor until it touches the bottom of the stilling well and then pull it up slightly and secure the cable. The pipe should have several ½" diameter holes drilled near the sensor location in order to eliminate any velocity effects on the sensor. In addition, a smaller ¼" hole should be drilled near the top of the pipe to allow air movement when the water goes up and down. A standard slip cap or a locking well cap can be used to secure the WL15. The pipe can also be adapted for a screw-on cap.

*See **Appendix B: Worksheets**, page 38

- In areas where vandalism is prevalent, 4” diameter galvanized steel pipe may be used for any exposed pipe. Plastic pipe, adapted to the steel pipe above water, may be used for the underwater section. A screw-on galvanized cap can then be used to cover the data logger. Two small pipe wrenches are required to access the WL15, but this installation is essentially bulletproof and vandal-proof.

Special Installations

- For flumes and weirs Global Water provides the Weir Stick Water Level Logger. This logger/sensor combination can be mounted inside a 2” diameter pipe that acts as its own stilling well, or the Weir Stick can be mounted in an existing stilling well. The weir stick is 3’ overall in length with a 2’ measuring range.
- For measuring pressure in pipes, the level sensor may be purchased with a ¾” NPT thread on the sensing end. The sensor threads can be adapted to existing ball valves with standard pipefittings.
- The WL15 Sewer Pipe Flow Option includes a level sensor built into a protective “mouse” housing and attached to a 12” stainless steel strap. When the sensor/straps are installed at the invert of a sewer or in a pipe, the data logger can be attached to a sewer’s stair rungs. If there is enough slack in the cable, the data logger can be accessed from the manhole above the stair rungs.
- When installed in a pipe that is under 12” diameter, the steel straps spring into the pipe, holding the sensor in place. Additional fasteners are usually not required for this type of installation.
- For a sewer pipe over 12” diameter, the sensor’s steel straps must be mounted into the pipe. The straps can be secured with molly or concrete bolts, or with marine-grade epoxy.

Storing the WL15

The WL15 may be stored without any special provisions. Place the datalogger and sensor inside a bag to keep the instrument clean and store on a shelf or hang on a wall.

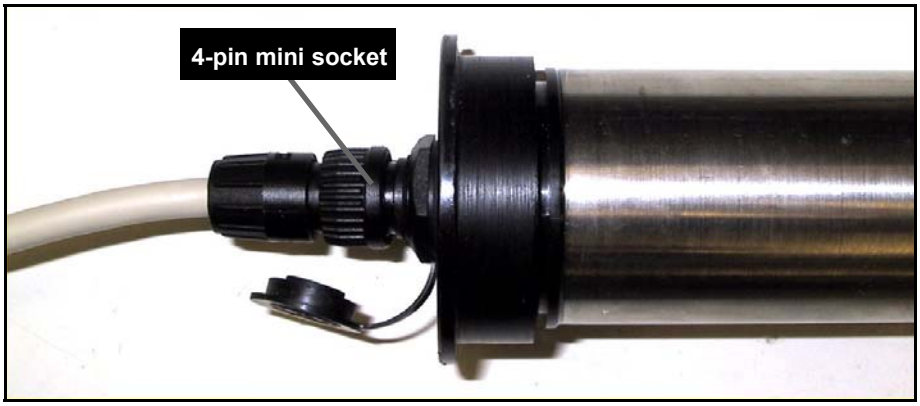
Using Global Logger Software

3

Hardware Connection

Connect the DB-9 female connector of the included communication cable (RS232C) to the COM 1 serial port on your computer. If COM 1 is being used, either disconnect and/or disable the device on COM 1 or connect to COM 2*.

Connect the 4-pin mini socket of the communication cable (RS232C) to your WL15 COM port.



Global Logger Startup

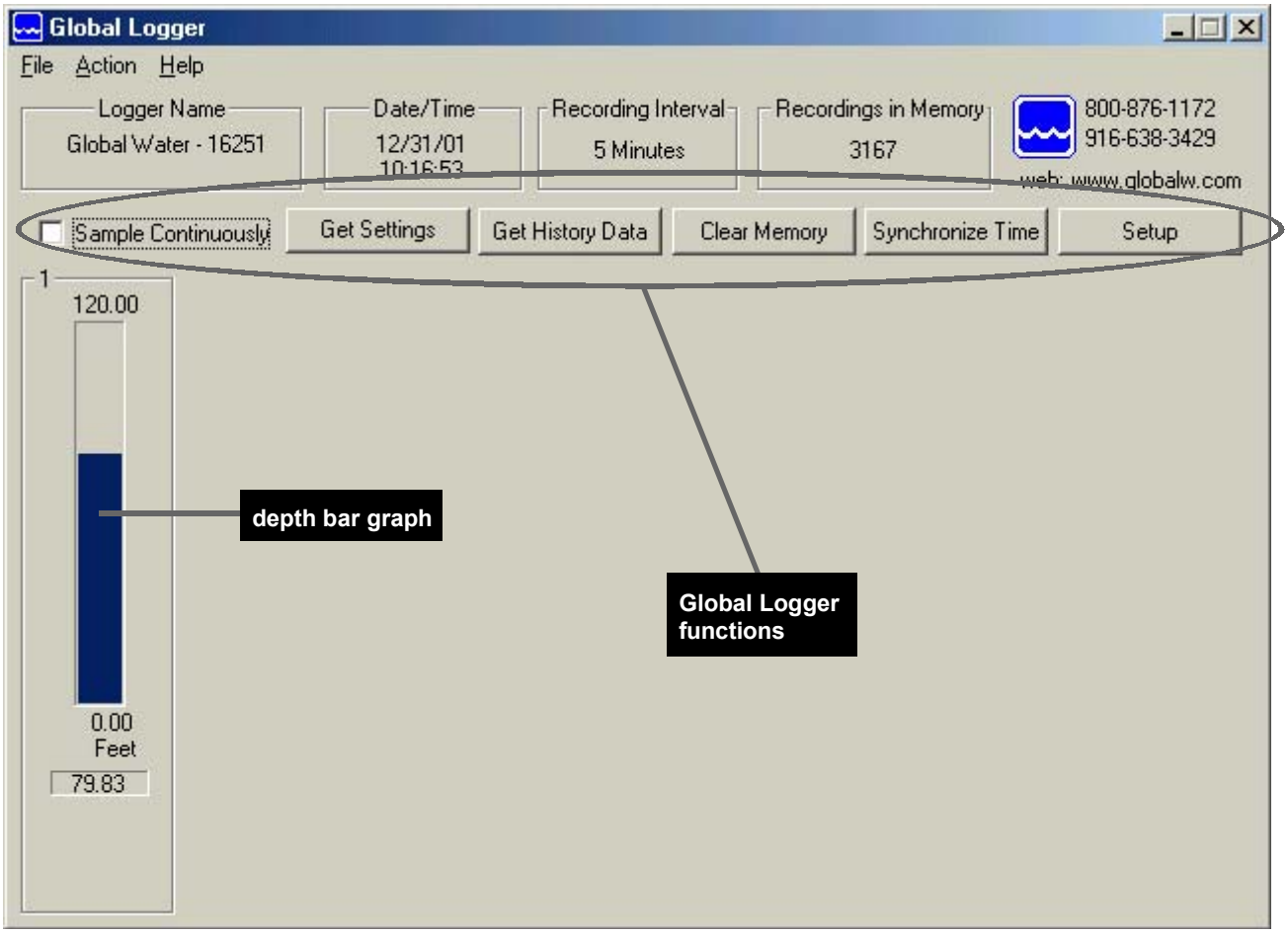
Double-click the Global Logger icon on your desktop if you created a desktop shortcut during software setup. Otherwise, access the directory in which your the **Global Logger.exe** file is stored and double-click on the file. If you have not installed the Global Logger software or if you want to create a desktop icon, see **Global Logger Software Installation****.

* See **Comm Failure**, page 32.
See **Global Logger Software Installation, pages 10 – 14

The Global Logger main window will display data in the following fields: **Logger Name**, **Date/Time**, **Recording Interval** and **Recordings in Memory**.

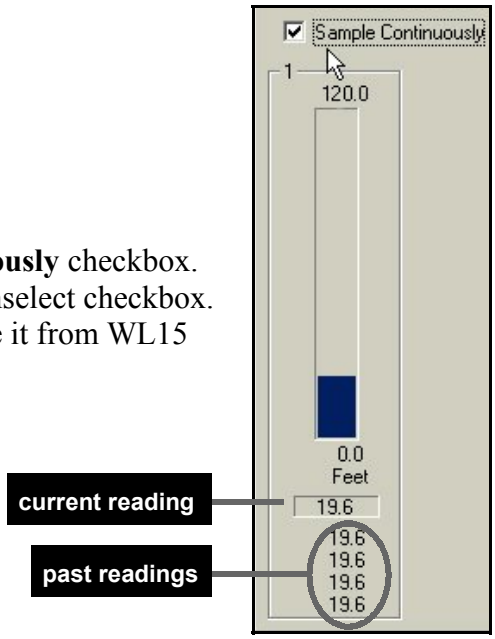
Access the Global Logger functions **Sample Continuously**, **Get Settings**, **Get History Data**, **Clear Memory**, **Synchronize Time** and **Setup** through the main menu check box and buttons. All Global Logger functions can also be accessed through **Action** on the menu bar.

The bar graph on the left side of the screen indicates current depth of sensor. For example, the graph in the following screen shot displays a 120 foot sensor with a reading of 79.83 feet. This data indicates that the sensor is currently at a depth of 79.83 feet. Sensors are calibrated to a variety of unit specifications (i.e. meters), so your bar graph readings may differ slightly.



Global Logger Functions

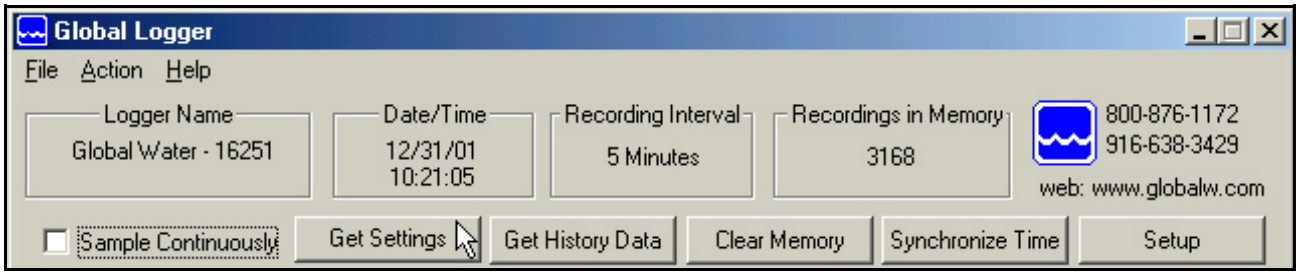
Sample Continuously/Real-Time Values



To display real-time values every second, select the **Sample Continuously** checkbox. Readings will display below the depth bar graph. To stop readings, unselect checkbox. Note, that real-time data is not recorded; therefore, you cannot retrieve it from WL15 memory.

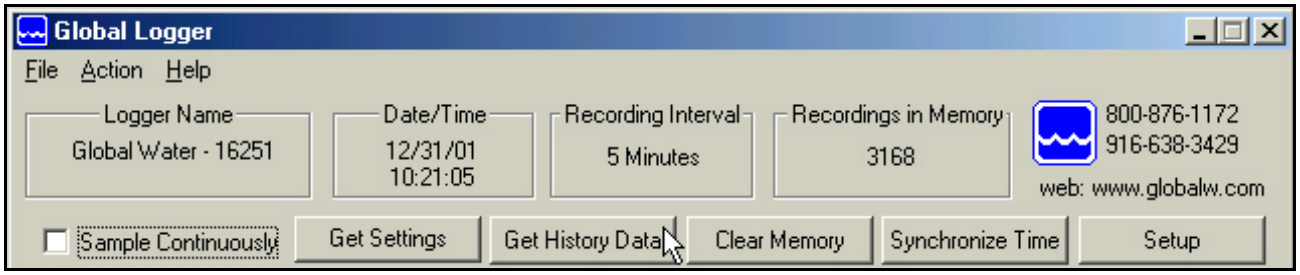
Get Settings

To refresh information in the Global Logger main window, click the **Get Settings** button. This action will update the **Logger Name**, **Date/Time**, **Recording Interval** and **Recordings in Memory** fields.



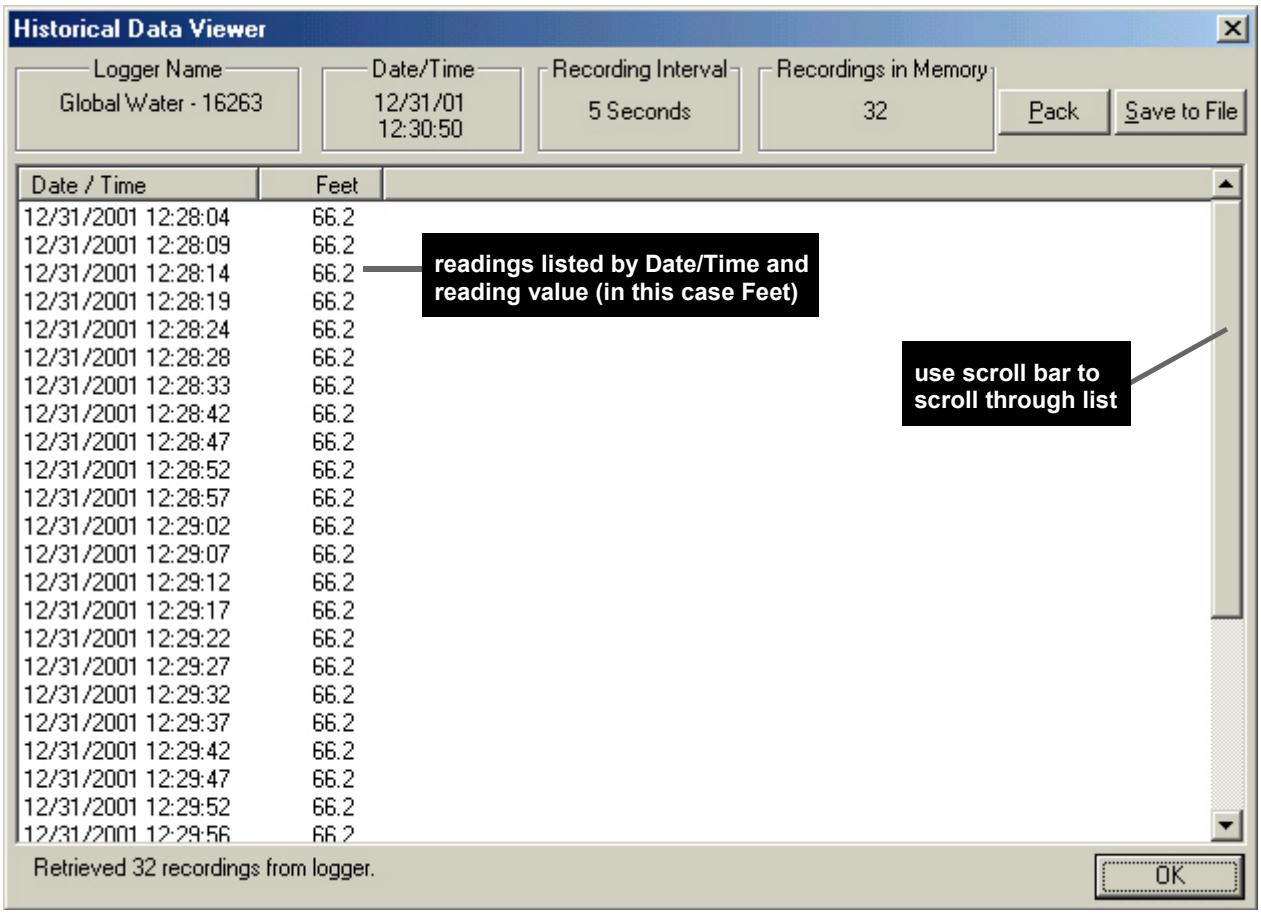
Get History Data

To retrieve logged data from memory, click the **Get History Data** button. The speed of your upload will depend on the number of data points recorded (more recordings equals longer upload time). To minimize long upload times, clear memory* after backing it up to disk**.

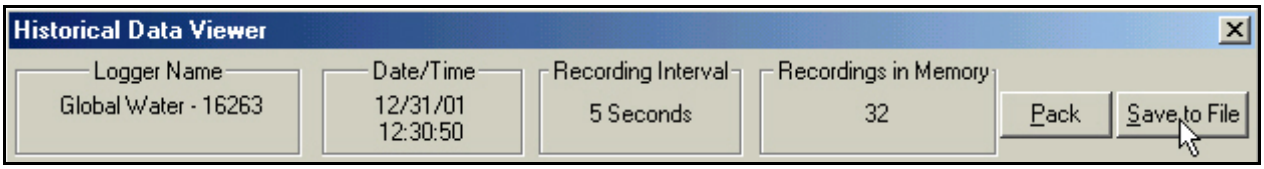


* See **Clear Memory**, pages 21 – 22
See **Get History Data, pages 20 – 21

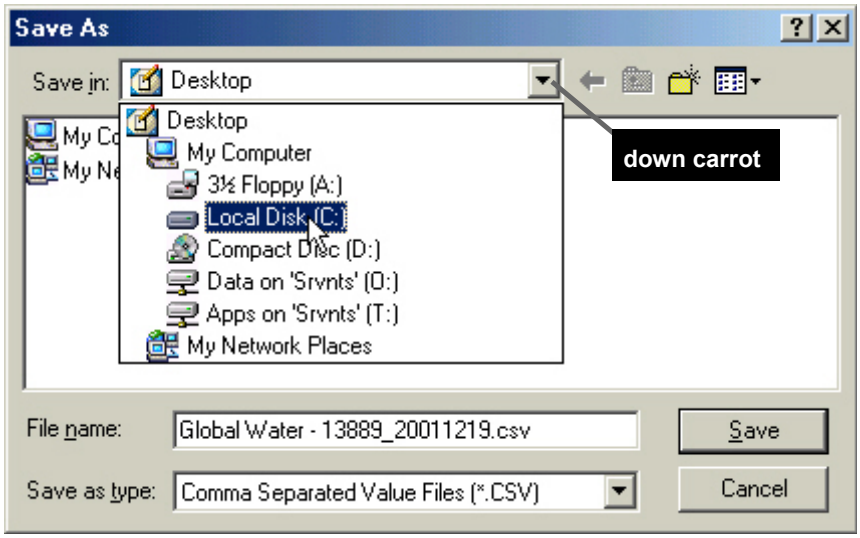
A **Historical Data Viewer** window will display. This window lists each data point by date/time and reading value. If there are more data points in memory than will fit in the data view window, use the scroll bar to scroll through the list of readings.



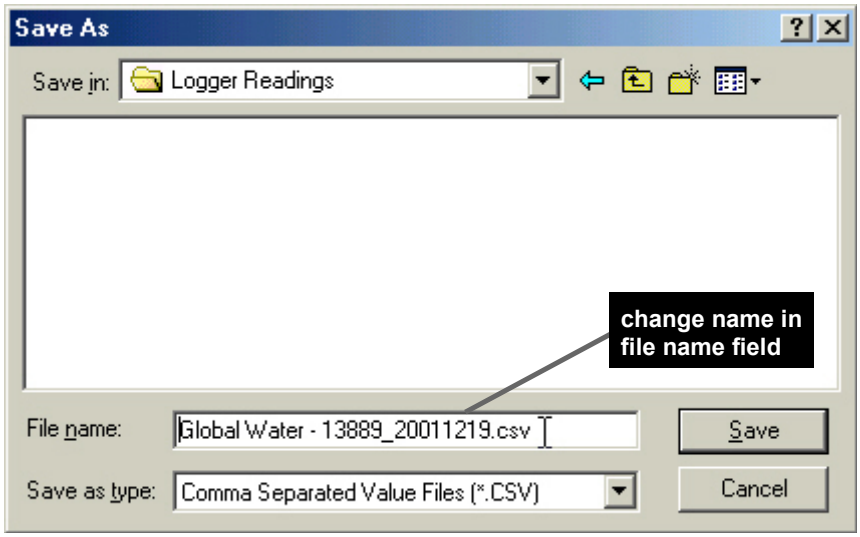
If you want to save current readings, click the **Save to File** button.



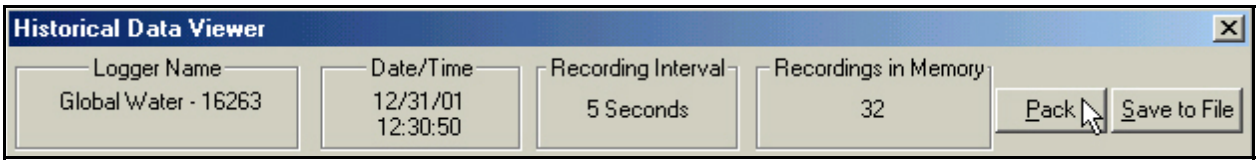
A **Save As** window will display. If you want to save your file to a directory other than the one displayed, click the down carrot of the **Save in:** field and click on the device (i.e. hard disk drive, floppy disk drive, etc.) you want to save the file to.



Double-click the directory or subdirectory you want to save to. If you want to change the file name click anywhere in the **File name:** field and type the desired name. However, do not change the .csv extension. This extension ensures the file will be recognized as a comma separated value (*.CSV) file. You can open CSV files in spreadsheet programs such as Microsoft Excel*. Click **Save** to save the file.



To remove zero readings, click the **Pack** button. Note, this operation will not remove the initial zero reading. Since the pack function does not change the readings stored in memory, you will need to **Save to File** to preserve the pack operation. If you exit and then reenter the **Historical Data Viewer** window, all readings (including zero readings) stored in memory will display regardless of any prior pack operation.

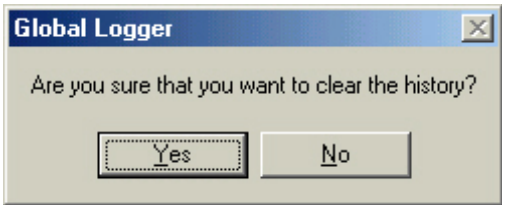


Click **OK** to exit the **Historical Data View** window.

Clear Memory

To clear your WL15's memory of readings click the **Clear Memory** button.

A confirmation dialog box will display. Click **Yes** to clear history or **No** to keep readings.

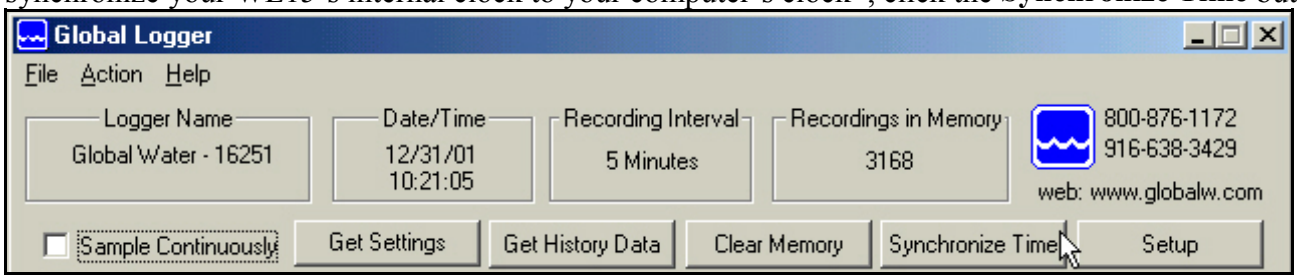


*Windows® Excel is a trademark of the Microsoft Corporation

If you click **Yes**, a **Standby** graphic will display in the middle of your monitor screen while the memory is purged.

Synchronize Time

To synchronize your WL15's internal clock to your computer's clock*, click the **Synchronize Time** button.

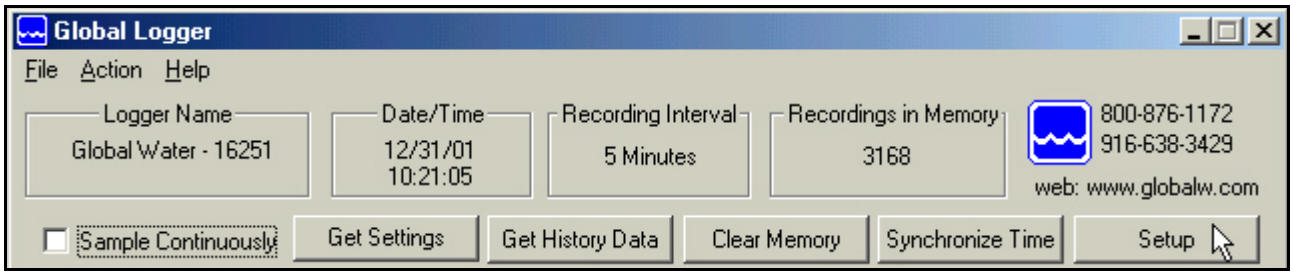


A **Standby** graphic will display in the middle of your monitor screen while synchronizing.

Setup

Note that your Water Level Logger has come completely setup from our factory. It has been calibrated and tested for optimal accuracy and performance. If you choose to recalibrate your sensor, use the following procedures.

To begin calibration and/or to change time interval settings, click the **Setup** button. A **Global Water Setup** window will display.



*See **System Time Check**, pages 9 – 10

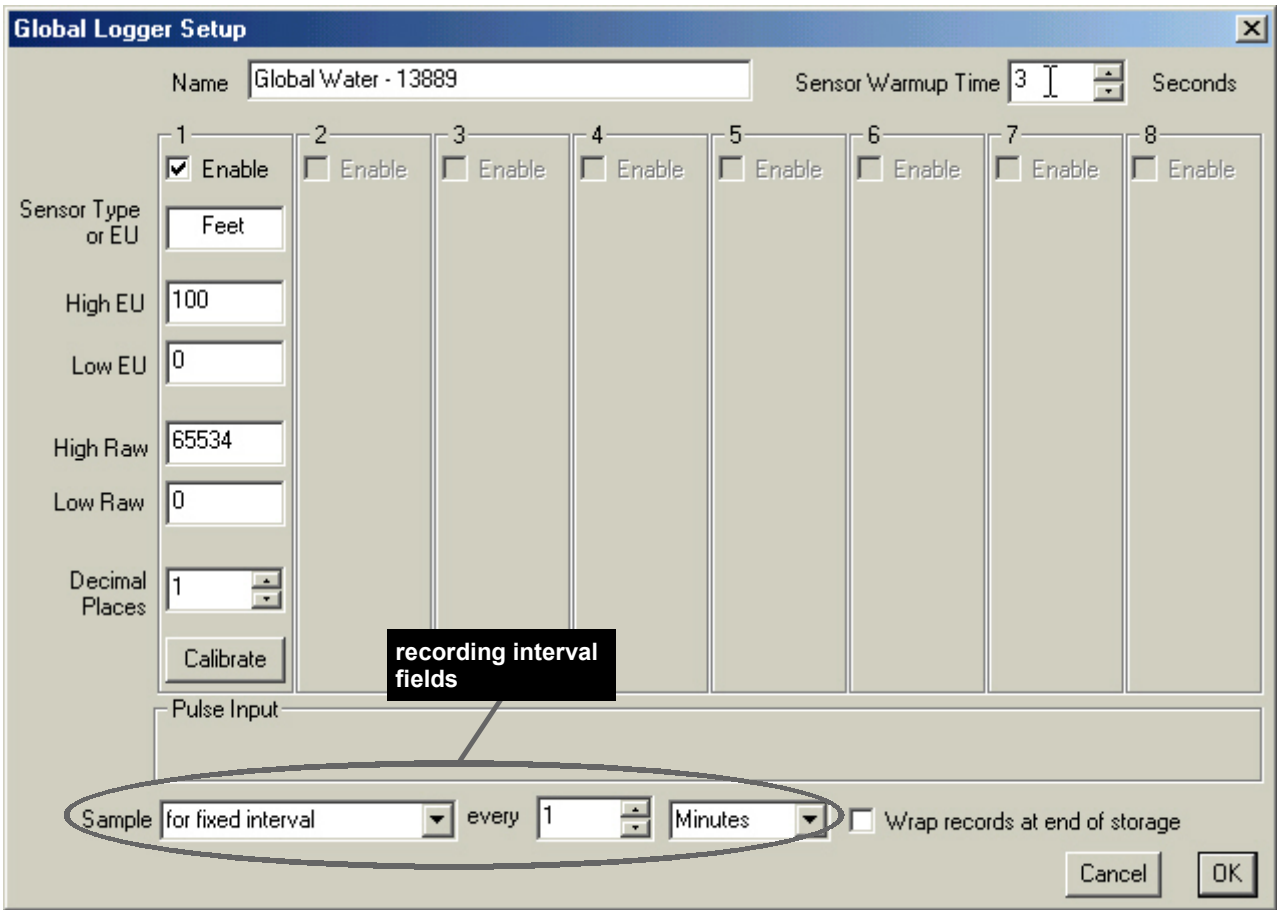
Datalogger Name and Sensor Warmup Time

If you want to change the datalogger name, click in the **Name** field and type in a new name.

Global Water recommends that the **Sensor Warmup Time** field be set at 3 seconds to supply the level sensor with adequate power for accurate data measurements. This setting dictates the length of time power is applied to the level sensor before the datalogger takes a reading.

For example, if you set your WL15 to record a reading every 20 minutes at fixed intervals and the process begins at 12:00:00, power will be applied to the level sensor immediately and a reading taken at 12:00:03. At 12:20:00, power will again be applied to the level sensor, and the datalogger will take a reading at 12:20:03. Note that if the recording interval fields are less than or equal to the **Sensor Warmup Time** field, the sensor is powered continuously.

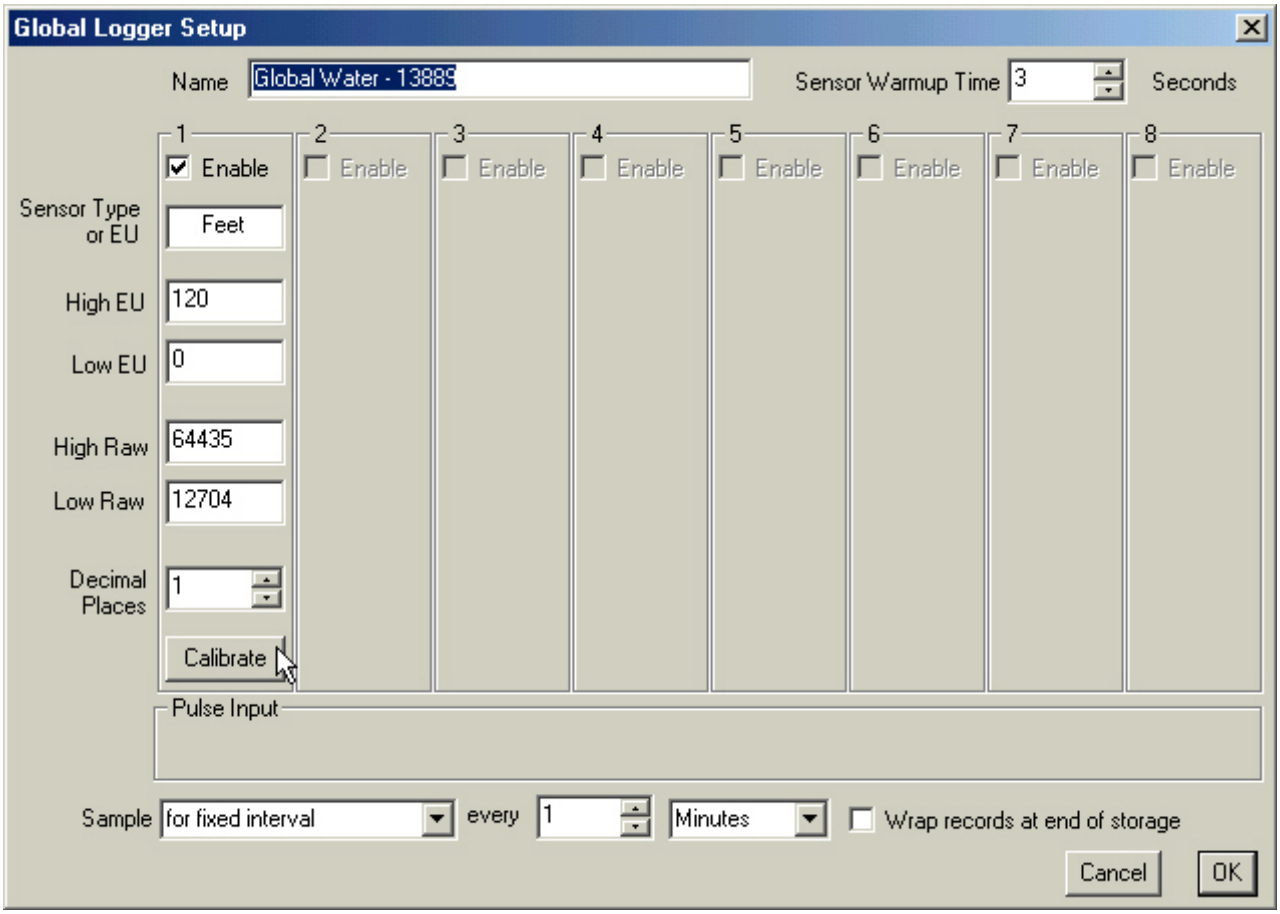
To change warmup time, click in the **Sensor Warmup Time** field and enter the desired time (0 –15 seconds). You may also click the up/down arrows to the right of the text field to increase or decrease the value by 1.

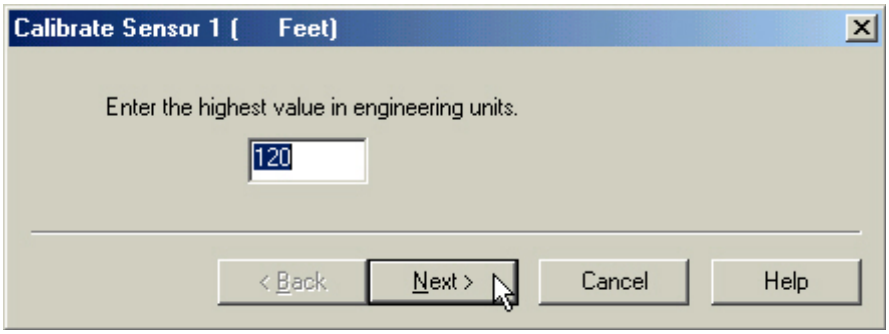


Calibration

Change the **Sensor Type or EU** (engineering units) field to the unit type you are calibrating to (i.e. meters, feet, etc.) by clicking in the field and typing the unit name. Note that the **Sensor Type or EU** field is only a text label. Actual readings are determined by the following calibration steps.

In case you make a mistake during the calibration process, write down the existing values in the **High Raw** and **Low Raw** fields before continuing (in this case **64435** and **12704**). Click the **Calibrate** button.

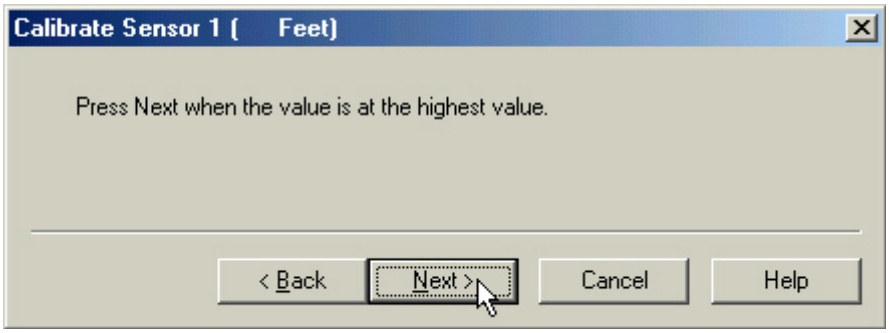


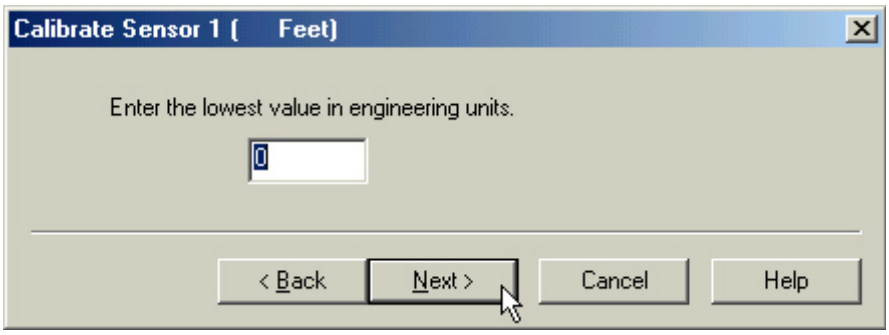


Enter the maximum unit range of the level sensor (**120** for a 120' sensor in this example) in the **highest value** text field and click the **Next** button.

If performing a dry calibration, insert the sensor into your water pressure meter and set to full scale range of your WL15. If performing a wet calibration, insert level sensor to a water depth of at least 10% of full scale range. For example a 120' sensor should be calibrated at a depth of at least 12'. Calibrating at greater percentages (up to 100%) provides greater accuracy. Calibration depth should be measured from water surface to sensor tip.

For both wet and dry calibrations, wait at least five seconds for the level sensor to adjust to current PSI level. Click the **Next** button.

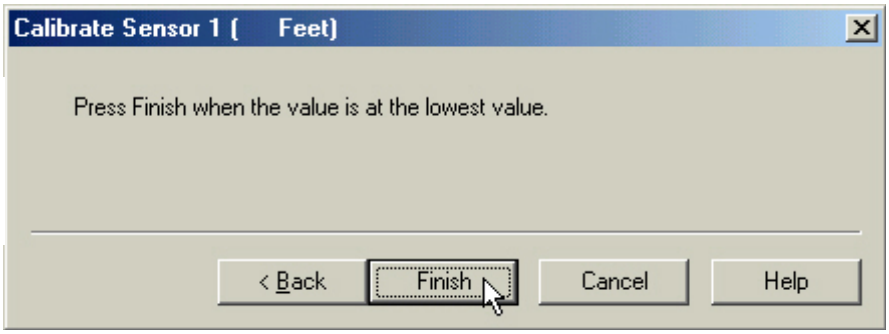


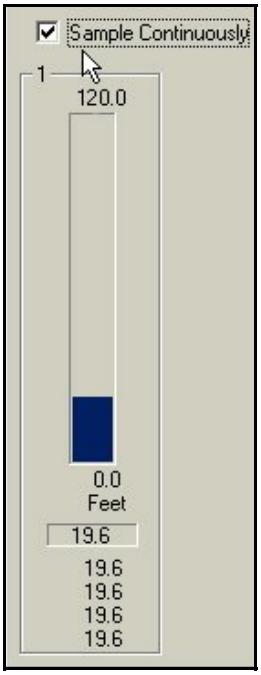


Enter **0** in the **lowest value** text field and click the **Next** button.

For dry calibrations, release the level sensor from water pressure meter. For wet calibrations, take level sensor out of water.

For both wet and dry calibrations, wait at least five seconds for the level sensor to adjust to 0 PSI. Click the **Finish** button.



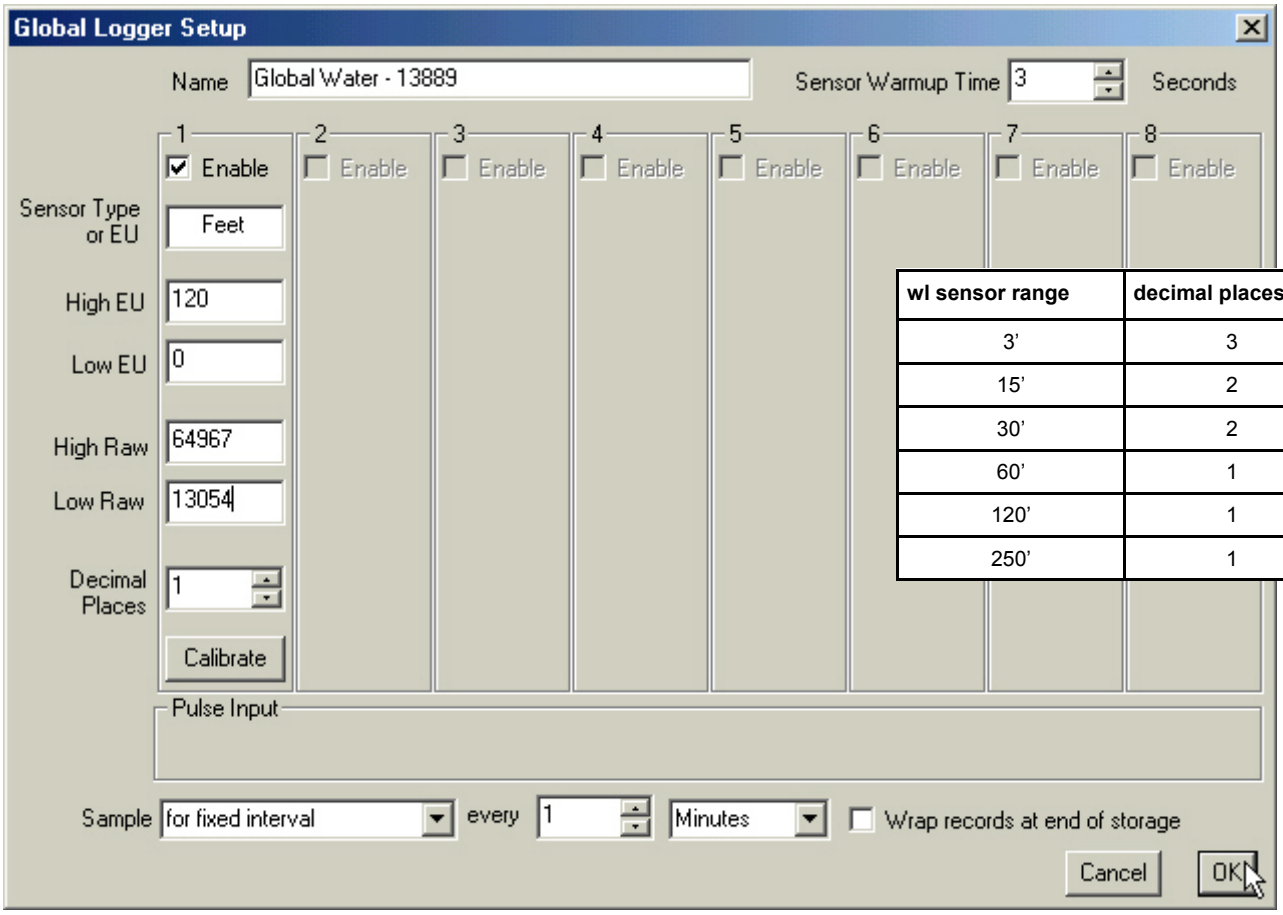


Note, that if performing a wet calibration at a fraction of total sensor range, the bar graph on the left side of the main **Global Logger** window will interpret full scale range at the calibration depth instead of actual total sensor range. All other logger operations will perform correctly. To revise calibration settings so that the graph will function correctly, follow the worksheet **Calibrating the Bar Graph to Higher or Lower Range** in **Appendix B***.

*See **Appendix B: Worksheets**, pages 37

Verify that **High EU** and **Low EU** fields reflect desired unit readings. Also, verify that the **High Raw** field reflects a range of 60,000 – 65,000 and that the **Low Raw** field reflects a range of 10,000 – 15,000.

Adjust the **Decimal Places** field according to the following chart (i.e. a 3' sensor should be adjusted to three decimal places).



wl sensor range	decimal places
3'	3
15'	2
30'	2
60'	1
120'	1
250'	1

Recording Interval and Memory Management

Select the interval type by clicking the down carrot of the **Sample** field. To repeatedly record values at a specified interval, click **for fixed interval**.

Note, that if you choose to record at fixed intervals, memory will fill up according to chart on the right. Refer to battery maintenance chart for battery life to available memory comparisons*.

Recording Interval	Time
1 second	6 hours, 49 minutes
1 minute	17 days
5 minutes	84 days
15 minutes	254 days
30 minutes	509 days
1 hour	1018 days

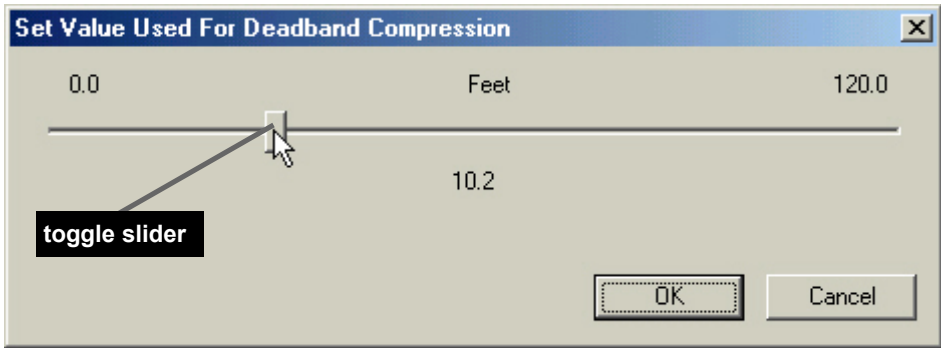
*See **Battery**, page 29

To record values according to a logarithmic curve, click **for logarithmic interval**. See chart for timeline specifications.

Time Frame	Readings per time unit	Expected total readings during Time Frame
0-19 seconds	As fast as possible	1000
20-59 seconds	1 per 1 second	40
60-599 seconds	1 per 12 seconds	45
10-99 minutes	1 per 2 minutes	45
100-999 minutes	1 per 200 minutes	45
1000-9999 minutes	1 per 1440 minutes	45

To take readings upon exceeding a specified unit range, click **upon exception**. This setting sets the logger to record a single reading after detecting a ± variance from the previously recorded exception reading. Click the long bar appearing at the bottom of the **Global Logger Setup** menu

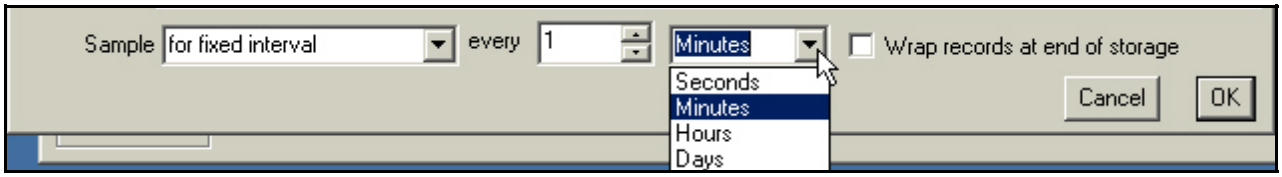
Click and hold toggle slider with left mouse button (i.e. do not click and release). Move slider left or right to select desired exception range, and release mouse button. Click **OK** to preserve selection or **Cancel** to revert to the previous setting.



The bar should change to reflect the latest exception setting. The setting in these screenshot examples sets the logger to record a single reading after water level changes (rises or falls) by 10.2 feet from the previous exception reading.

Set the recording interval digit, by clicking in the **every** text field, and typing the desired number. You may also click the up/down arrows to the right of the text field to increase or decrease the value by 1.

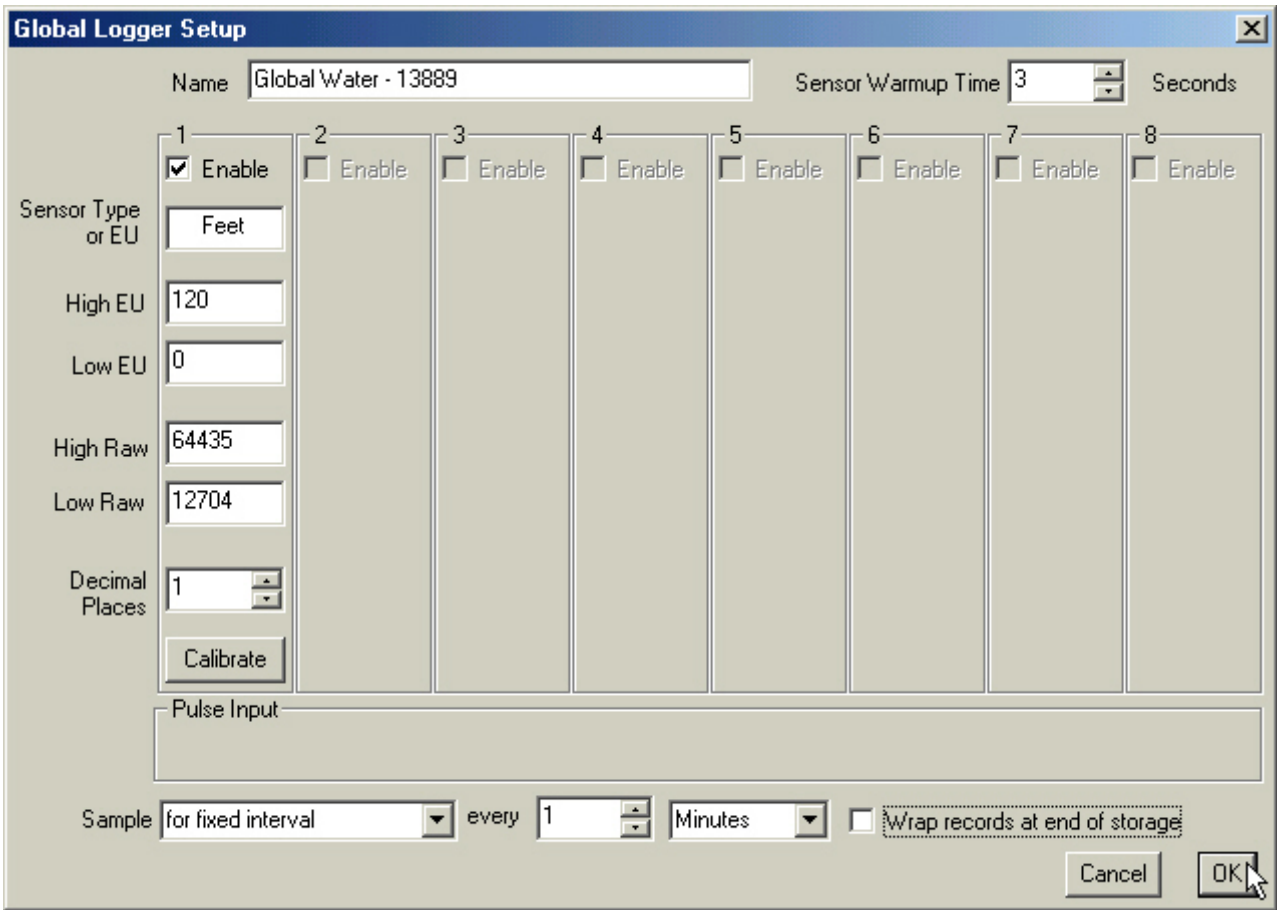
Set the recording interval time unit, by clicking the down carrot of the time unit field (not labeled) and clicking **Seconds**, **Minutes**, **Hours** or **Days**.



The **Wrap records at end of storage** checkbox dictates whether or not the logger continues to record readings after its memory is filled. To overwrite readings in synchronous order (earliest readings are overwritten first) after memory is filled, click the checkbox. To preserve readings and stop recording after memory is filled, leave box unchecked.

After calibrating and/or changing interval recording settings, click the **OK** button. To cancel changes, click **Cancel**.

You may also manually change WL15 settings directly using a terminal program*.



*See **Appendix D: Terminal Programming**, page 40

Maintenance

4

Battery

Global Water recommends that the battery voltage be physically checked based on your recording interval*. Refer to the following table.

Note, that the WL15 uses 60µA while "sleeping" and 3mA plus the signal current while taking readings. This table is based on the worst-case scenario where the sensor is providing the maximum signal of 20mA.

Temperature can also affect battery life. A WL15 in an environment that has a sustained temperature of 23° C will run 5% longer than a unit that has a sustained temperature of 0° C.

Recording Interval	Theoretical Battery Life	Recommended Time Between Battery Check
1 second	43 hours	36 hours
1 minute	34 days	1 month
30 minutes	424 days	6 months
1 hour	526 days	6 months
1 day	685 days	6 months

Checking the battery requires that the WL15 cap be unscrewed. The battery should be visible and can be gently removed from the housing with fingers or a pair of pliers.

*See **Recording Interval and Memory Management**, pages 26 – 28

The battery must be disconnected from the battery strap. **Note, that the WL15 will stop recording, but will not lose any recordings or settings**.

Test the battery with a voltage meter. The sensor will not work reliably if the battery voltage is below 7.5V. If the battery needs to be replaced use a 9V lithium battery for reliable service. Re-attach the battery to the battery strap and gently slide it into the housing. Screw the cap on to the data logger housing, being careful not to pinch any of the wires.

Calibration

The level sensor's calibration must be periodically verified. Global Water recommends checking the sensor's calibration with a sounder or other measuring device once every 6 months.

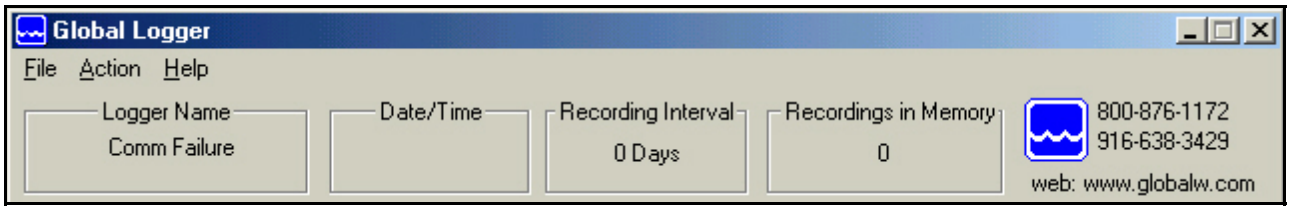
Sensor Screen Cleaning

The screen on the end of the sensor must be periodically checked for clogging from mud and sludge. Wash the screen with clean water and/or scrub it gently with a toothbrush. Do not insert objects through the screen, as this may cause damage to the sensor.

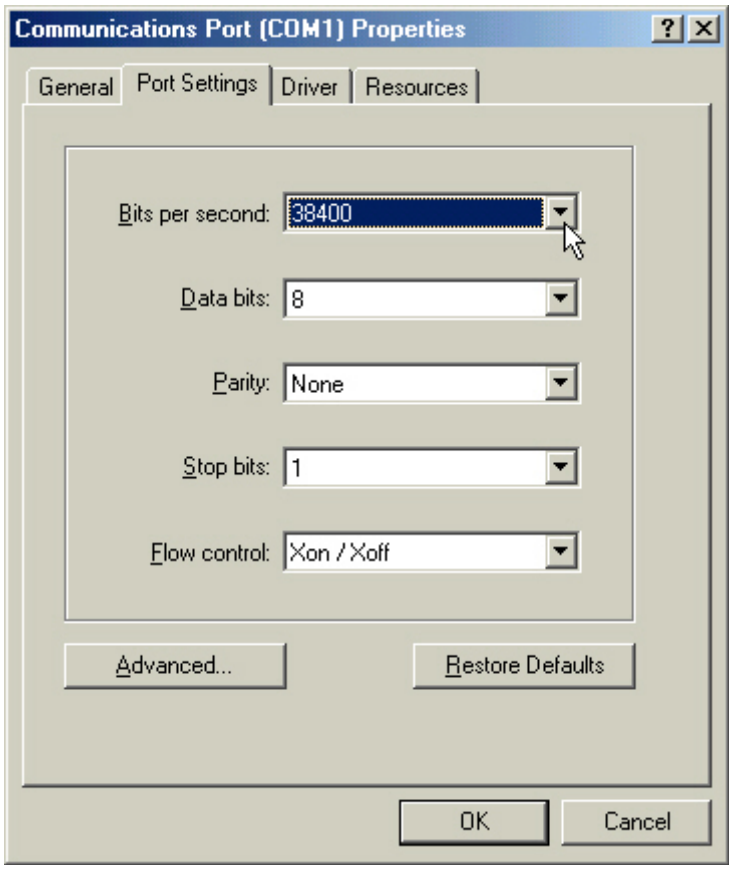
Troubleshooting 5

Comm Failure

If Global Logger software displays **Comm Failure** in the **Logger Name** field, perform the following steps

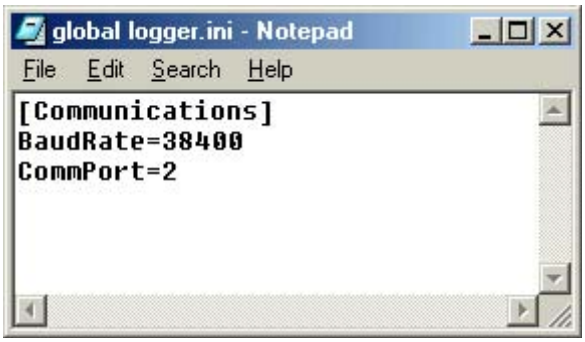


- Verify that the communication cable is securely connected to the data logger and to your computer*.
- Check the battery voltage on the logger**.
- Make sure that your computer is correctly set up to use your communication channel 1 (COM 1). Refer to the settings below for comparison.



* See **Hardware Connection**, page 17
See **Battery, page 29

- If you only have access to COM 2, then an *.ini file must be created. Open **Notepad** and type the text exactly as it appears in the following screenshot. Change the directory to the **Windows** folder of your main drive if you are using Windows 95, 98, ME or XP or to the **WINNT** folder of your main drive if you are using Windows NT or 2000. Save the file as **global logger.ini**.



- Make sure that no other software or device is using COM 1, such as an infrared port or palm synching software.

Sensor Reading Incorrectly

- Verify that the vent tube has not been kinked or sealed. The sensor uses this tube to compensate for barometric pressure changes.
- Clean the sensor following the maintenance instructions*.
- Recalibrate the sensor using the calibration methods described in the **Calibration** section of this manual**.

Water in the Vent Tube

If water gets into the cable's vent tube, place it next to a heater for 24 hours to dry the inside of the cable.

Other Issues

- Refer to the manual for proper set-up.
- Check all connections.
- Call Global Water for tech support: 800-876-1172 or 916-638-3429 (many problems can be solved over the phone). Fax: 916-638-3270 or Email: **globalw@globalw.com.** When calling for tech support, please have the following information ready;

  1. Model number
  2. Unit serial number
  3. P.O. number the equipment was purchased on.
  4. Our sales number or the invoice number.
  5. Repair instructions and/or specific problems relating to the product.

  Be prepared to describe the problem you are experiencing including specific details of the application, installation, and any additional pertinent information.

* See **Sensor Screen Cleaning**, page 30
See **Calibration, pages 24 – 26

- In the event that the equipment needs to be returned to the factory for any reason, please call to obtain an RMA number (Return Material Authorization). Do not return items without an RMA number displayed on the outside of the package.

  Clean and decontaminate the WL15 if necessary.

  Include a written statement describing the problems.

  Send the package with shipping prepaid to our factory address. Insure your shipment, since Global Water's warranty does not cover damage incurred during transit.

Warranty

6

Global Water Instrumentation, Inc. warrants that its products are free from defects in material and workmanship under normal use and service for a period of one year from date of shipment from the factory. Global Water's obligations under this warranty are limited to, at Global Water's option: (I) replacing or (II) repairing; any products determined to be defective. In no case shall Global Water's liability exceed the products original purchase price. This warranty does not apply to any equipment that has been repaired or altered, except by Global Water Instrumentation, Inc., or which has been subject to misuse, negligence or accident. It is expressly agreed that this warranty will be in lieu of all warranties of fitness and in lieu of the warranty of merchantability.

The warranty begins on the date of the invoice.

Appendix A: WL15 Detailed Specifications

A

Datalogger

Inputs

- Channels: 1 Analog
- Range: 4 – 20 mA
- Storage Resolution: 1 / 65535 (16 bit)
- A/D Resolution: 1 / 4095 (12 bit)

Data Storage

- Memory Size: 2MB (24,000 recordings)
- Type: non-volatile Flash
- Intervals: 1 – 256 seconds, 1 – 256 minutes, 1 – 256 hours, or 1 – 256 days
- Time Accuracy: 0.0015%
- Time Format: Month / Day / Year Hour / Minute / Second

Communication

- Speed: 38,400 kbs
- Data Transfer: 2MB / 4 min.
- Type: RS232C (Serial)

Electrical

- Battery: 9V Lithium (1A / h)
- Back-up Battery: 3V Lithium (950 mA / h)
- Sleep Current: 60µA
- Wake Current: 3 mA + Sensor (4 – 20 mA)
- Communication Current: 100 mA

Environmental

- Operating Temperature: -40 to 75° C (-40 to 170° F)
- Storage Temperature: -50 to 90° C (-60 to 200° F)
- Humidity: 0 to 95% Non-Condensing (Conformal Protection Coating)

Physical Dimensions

- Body OD: 45mm (1.77”)
- Cap OD: 57mm (2.24”)
- Length: 315mm (12.4”)
- Weight: ~450g (16 oz.)

Sensing Element

- Output: 4 – 20 mA
- Range: 0 – 3’, 0 – 15’, 0 – 30’, 0 – 60’, 0 – 150’, 0 – 250’
- Accuracy: ±0.2% FS (35° F to 70° F)
- Linearity and Hysteresis: ±0.1% FS
- Resolution: Infinitesimal (Analog)
- Operating Voltage: 10 – 36 VDC
- Current Draw: 4 – 20 mA
- Warm-up Time: 10 ms minimum
- Operating Temperature: -40 to +85°C (-40 to +185°F)
- Size of Probe: 3/4" diameter x 4 1/2" long
- Weight: 0.5 lb
- Overpressure: X4
- Burst Pressure: X10
- Material: Fluorosilicone
- Type: Differential (Wet/Wet)
- Compensated Temperature Range: 0 to 50°C (32 to 122°F) submerged

Housing

- Material: 304L SS
- Diameter: 19 mm (0.75”)
- Length: 200 mm (8”)
- Weight: ~115g (4 oz)

Cable

- Conductors: 4 each 22 AWG
- Jacket Material: 87A shore hardness Polyurethane
- Optional Jacket: Fluorinated Ethylene Propylene (FEP) Teflon
- Cable OD: 7.8 mm (0.307”)
- Vent Tube: HD Polyethylene
- Shield: Aluminum Mylar
- Temperature range: -30 – 85°C (-22 – 185°F)
- Weight: ~65 g / m (0.7 oz / ft)

Appendix B: Worksheets

B

Calibrating the Bar Graph to Higher or Lower Range

With some sensors it is either impractical or unfeasible to reach the full-scale or lower scale of its range. This will not affect the actual reading of the datalogger but it will cause the bar graph to work incorrectly.

Here are the equations for finding new limits on the bar graph. First take the two coordinates that were found during calibration*.

(High EU _____, High Raw _____) and
(Low EU _____, Low Raw _____).

Now calculate the slope using this equation:

m = (High Raw – Low Raw) / (High EU – Low EU)
m = _____

Next find the y-intercept:

b = High Raw - (m x High EU)
b = _____

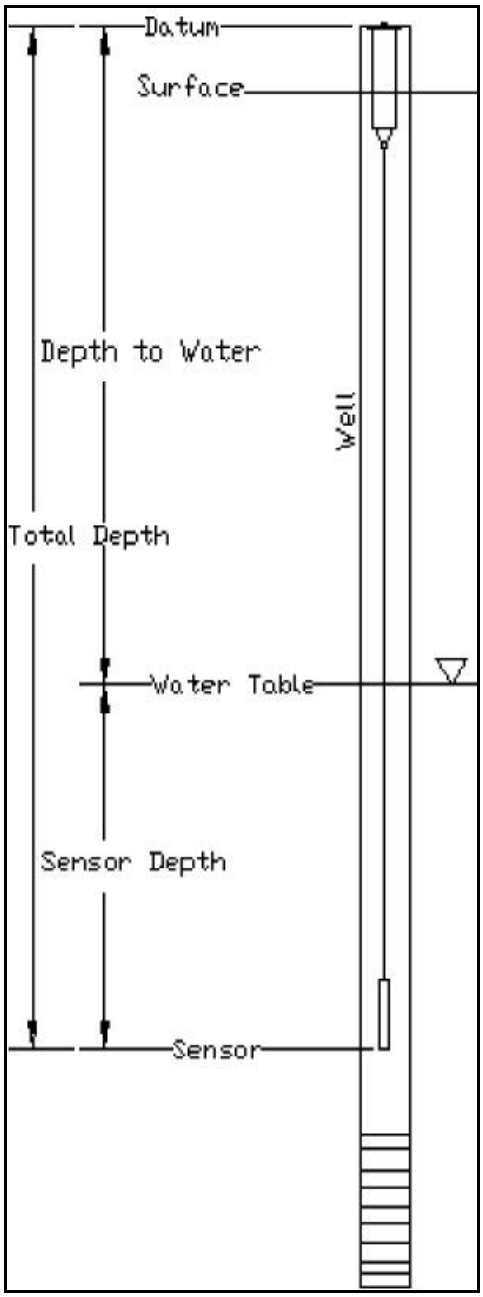
Now you can calculate the new "Raw" value for any Engineering Unit.

New Raw = (m x New EU) + b
New Raw = _____

Finally, enter these new "Raw" values into your datalogger and verify the readings are correct*.

*See **Calibration**, pages 24 – 26

Calibrating Level Sensors for Depth to Water Readings



Note, that to take depth to water readings, the bar graph must be calibrated to the full scale of the sensor. Follow the worksheet **Calibrating the Bar Graph to Higher or Lower Range***.

The first step is to find the Total Depth of the sensor. This is the distance from the end of your sensor to your datum. (Cable lengths from the factory are not exact. You may need to measure for precise distances.)

Total Depth = _____

Next, find the maximum Sensor Depth (range of the sensor). In the **Calibration**** section of the software, you can find this value by using the following equation:

Sensor Depth = | High EU_____ - Low EU_____ |
Sensor Depth = _____

Now you can find your new Engineering Units using these steps:

New Low EU = Total Depth
New Low EU = _____

New High EU = Total Depth – Sensor Depth
New High EU = _____

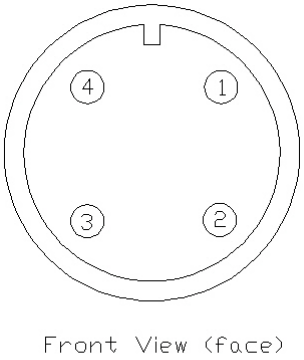
Finally, enter these New EU values into your datalogger and verify the readings are correct**.

* See **Appendix B: Worksheets**, page 37
See **Calibration, pages 24 – 26

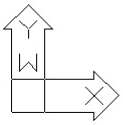
Appendix C: Cable Configuration

C

The following diagram details the pin layout of the male communications cap on the WL14/15 Datalogger series. The chart explains the communications wiring.



Comm. Cap Pin Number	Comm. Cap Wire Color	Function	9 pin D-sub Pin Number (Male)
1	Green	Dig. Ground	5
2	Blue	DTR	4
3	Violet	Rx	3
4	Red	Tx	2



Appendix D: Terminal Programming

D

Communication Commands for Windows Datalogger

The following is a chart of commands that can be sent to the Windows Datalogger through a terminal program.

Command	Description
D	Set Date
T	Set Time
?	Get number of data points
h	Get first historical data point
a	Get historical data point again
X	Abort
i	Get next historical data point (increment)
E	Erase
r	Get real time data point
!	Set description
1	Get description
@	Set Units
2	Get Units
#	Set Raw Scale
3	Get Raw Scale
$	Set Engineering Unit Scale (EU)
4	Get Engineering Unit Scale (EU)
N	Set Name
n	Get Name
S	Set Sample interval
s	Get Sample interval

APPENDIX H

Stream Flow Determinations SOP

Standard Operating Procedure for Streamflow Determinations

1.0 Summary

The following Standard Operating Procedure (SOP) for Streamflow Determinations is based upon the Massachusetts Department of Environmental Protection, Division of Watershed Management SOP for Flow Measurement. This method breaks the flow down into area and velocity components. Interval distances are decreased in the middle section to increase the resolution of the flow. Areas are determined through staff gauge readings and a surveyed stream bottom at each pre-selected point. Velocities are taken at varying intervals across the stream. The flow is determined for each segment and summed together to obtain the total flow for the stream. The low flow meter described below will be used in all streamflow measurements.

2.0 Equipment

To capture the required range of velocities a Marsh McBirney low velocity meter must be used. The Marsh McBirney 2000 Flo-Mate uses electromagnetic sensors to determine the velocity. The meter has zero stability of +/-0.05 ft/sec; accuracy of +/- 2% of reading + zero stability; and a range of –0.5 to +19.99 ft/sec.

Equipment/ Supply Checklist for Station Installation

Measuring Tape	Survey Tripod and Level
Duct Tape	Waders
Wooden Stakes	Field Book and Pen
Nails	Map of Stations
Loppers	Metal Fence Stakes
Staff Gauge	Hammer

Monitoring Equipment Checklist

Marsh McBirney 2000 Flo-Mate	Wading Rod
Field Book and Pen	Waders
Bucket	Map of Stations

3.0 Station Selection

Station location was determined based on the following criteria:

1. A relatively straight reach with a uniform cross- section
2. The site is relatively free of obstructions (such as fallen trees or boulders)
3. Laminar flow that is confined to a channel
4. Anticipated low flow conditions can be measured by the meter used
5. The site is safe to enter
6. Permanent staff gauge and measuring tape can be installed

4.0 Station Installation

Each station consists of a staff gauge and a measuring tape marked at each of the intervals at which velocities are taken.

1. Attach staff gauges to metal fence stakes.
2. Pound stakes into the streambed at the deepest point facing the bank. Set the staff gauge zero at the invert level (in culvert) or on the bottom of the stream channel. Survey the staff gauge to a reference datum using swing ties.
3. Establish a surveyed elevation for the staff gauge incase of damage/theft.
4. Put a measuring tape across the stream and stake it into both stream banks above the high water mark and perpendicular to the flow.
5. Mark the tape at site-specific intervals. Each station has at least 20 intervals. The intervals are closer together in deeper, faster moving areas. The intervals shall be between 6" and 2'.
6. Survey the streambed at each interval. This additional step enables us to accurately determine the depth of water in each segment.

5.0 Flow Measurements

Calibration:

1. Turn meter on and look for 'low battery' display. If display does not come on, proceed as follows. If light comes on, change batteries, then proceed with the following procedures.
2. Set meter reading to "Time constant filtering (RC)". Do this by simultaneously pressing the up/down arrows to toggle to the RC display. .
3. Fill bucket with water from stream. Insert probe into bucket, clear meter reading, and check for zero reading (no flow should be going on in bucket, thus zero reading).
4. If meter is not reading zero, initiate the zero start sequence by pressing the "STO" and "RCL" keys at the same time. The number 3 should appear.
5. Press the down arrow until the number displayed reaches 0.
6. The number 32 will appear on the screen. The unit will count down from 32 to 0, then turn itself off.

Measuring Stream Channel Flow:

1. Take a depth measurement, to determine proper location of probe placement, prior to each velocity reading.
2. Take velocity readings at each interval. This is done by placing the flow probe into the stream, facing into the direction of flow. The probe should be 1/3 of the way down from the surface of the water, and 2/3 of the way above the sediments. Stand 12-18" downstream from the probe to avoid affecting the flow. Keep wading rod still. Record velocity readings in field book. Continue until flow readings are collected for entire stream segment.
3. Take a reading off the staff gauge in the stream, record this number on the field sheet.

4. Record the interval of wetted perimeter of the stream.

Measuring Streamflow from a Culvert:

1. Take a depth measurement, to determine proper location of probe placement, prior to each velocity reading.
2. Take velocity readings at each interval across the culvert. This is done by placing the flow probe into the culvert, facing into the direction of flow. The probe should be 1/3 of the way down from the surface of the water, and 2/3 of the way above the bottom of the culvert. Stand 12-18" downstream of the probe to avoid affecting the flow. Keep wading rod still. Record velocity readings in field book. Continue until flow readings are collected for entire culvert.
3. Take a reading of the staff gauge in the stream, record this number on the field sheet.
4. Record the interval at the wetted perimeter of the culvert.

Calculating Streamflow:

The total streamflow is calculated using the summation of the flow in each segment. Streamflows are calculated by entering survey data, staff gauge readings and velocity readings into an excel spreadsheet. The staff gauge readings are correlated to the stream bottom using the survey data, which gives the depth of water for each segment. The width of each segment is defined as "the cross-sectional area bounded on each side of the vertical velocity measurement by a distance halfway to the preceding vertical and halfway to the following vertical" (DWM SOP Flow Management). This value is fixed and does not change from day to day. After the depth of water at each segment and the width of each segment are determined the following equation is used to determine the flow in each section:

FLOW = Depth of Water **x** Width of Segment **x** Velocity

The total streamflow is the summation of the flow in each segment.

APPENDIX I

YSI 55 & Hanna HI 98128 Calibration Instructions

5. Calibration

Dissolved oxygen calibration must be done in an environment with a known oxygen content. Since the amount of oxygen in the atmosphere is known, it makes an excellent environment for calibration (at 100% relative humidity). The calibration/storage chamber contains a moist sponge to create a 100% water saturated air environment.

5.1. Before You Calibrate

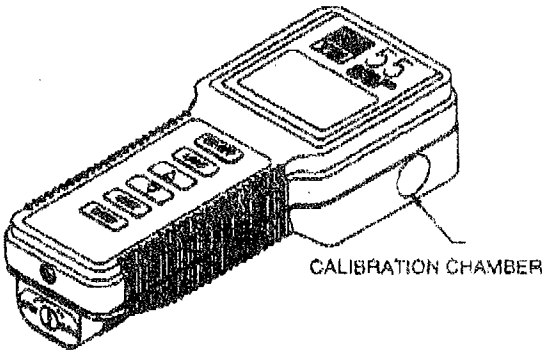
Before you calibrate the YSI Model 55, complete the procedures discussed in the *Preparing the Meter* and *Preparing the Probe* chapters of this manual.

To accurately calibrate the YSI Model 55, you will need to know the following information:

- The approximate altitude of the region in which you are located.
- The approximate salinity of the water you will be analyzing. Fresh water has a salinity of approximately zero. Sea water has a salinity of approximately 35 parts per thousand (ppt). If you are not certain what the salinity of the sample water is, use a YSI Model 30 Salinity-Conductivity-Temperature meter to determine it.

5.2. The Calibration Process

1. Ensure that the sponge inside the instrument's calibration chamber is wet. Insert the probe into the calibration chamber.
2. Turn the instrument on by pressing the **ON/OFF** button on the front of the instrument. Wait for the dissolved oxygen and temperature readings to stabilize (usually 15 minutes is required after turning the instrument on).
3. To enter the calibration menu, use two fingers to press and release both the **UP ARROW** and **DOWN ARROW** keys at the same time.
4. The LCD will prompt you to enter the local altitude in hundreds of feet. Use the arrow keys to increase or decrease the altitude.



EXAMPLE: Entering the number 12 here indicates 1200 feet.

5. When the proper altitude appears on the LCD, press the **ENTER** key. The Model 55 should now display **CAL** in the lower left of the display, the calibration value should be displayed in the lower right of the display and the current DO reading (before calibration) should be on the main display.

6. Make sure that the DO reading (large display) is stable, then press the **ENTER** button. The LCD will prompt you to enter the approximate salinity of the water you are about to analyze. You can enter any number from 0 to 40 parts per thousand (PPT) of salinity. Use the arrow keys to increase or decrease the salinity setting. When the correct salinity appears on the LCD (zero for fresh water), press the **ENTER** key. The instrument will return to normal operation.

Once the calibration process is complete, the only keys which will remain operational are the **MODE** key, the **LIGHT** key and the **ON/OFF** key. You can move back and forth from reading dissolved oxygen in the mg/L mode or the % air saturation mode by pressing the **MODE** key. If you are working in a dark area and have difficulty reading the LCD, press and hold the **LIGHT** key to activate the back-light of the YSI Model 55. The **ON/OFF** key turns the instrument on or off.

For best results:

- Each time the Model 55 is turned off, re-calibrate before taking measurements.
- Calibrate at a temperature within ±10°C of the sample temperature.

Note: The YSI 55 was calibrated for temperature reading when it was constructed. There is no manual calibration method available.

Additional Calibration Steps for Two Point Calibration

1.) Place probe into separate calibration chamber. Calibration chamber should be prefilled with a saturated solution of sodium sulfite with a trace of cobalt chloride.

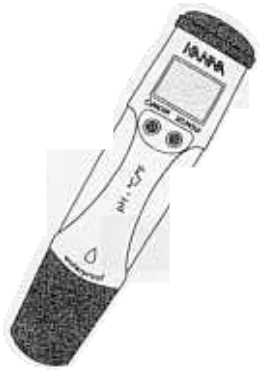
2.) Wait for DO readings to stabilize. DO should drop to less than 0.5 mg/l. If they do not drop below 0.5 mg/l, then the probe is damaged or was not prepared correctly.

3.) If readings are not less than 0.5 mg/l, the process "Preparing the Probe" will need to be repeated.

Instruction Manual

HI 98127 - HI 98128

Waterproof
pH & temperature meters



HANNA instruments
www.hannainst.com

These Instruments are in Compliance with CE Directives

WARRANTY

HI 98127 and **HI 98128** are **warranted for one year** against defects in workmanship and materials when used for their intended purpose and maintained according to instructions. **The electrode is warranted for a period of six months.** This warranty is limited to repair or replacement free of charge.

Damages due to accident, misuse, tampering or lack of prescribed maintenance are not covered.

If service is required, contact the dealer from whom you purchased the instrument. If under warranty, report the model number, date of purchase, serial number and the nature of the failure. If the repair is not covered by the warranty, you will be notified of the charges incurred. If the instrument is to be returned to Hanna Instruments, first obtain a Returned Goods Authorization Number from the Customer Service department and then send it with shipment costs prepaid. When shipping any instrument, make sure it is properly packaged for complete protection.

All rights are reserved. Reproduction in whole or in part is prohibited without the written consent of the copyright owner, Hanna Instruments Inc., Woonsocket, Rhode Island, 02895 , USA.

Hanna Instruments reserves the right to modify the design, construction and appearance of its products without advance notice.

Dear Customer,

Thank you for choosing a Hanna product. This manual will provide you with the necessary information for correct operation. Please read it carefully before using the meter.
If you need additional technical information, do not hesitate to e-mail us at **tech@hannainst.com**
These instruments are in compliance with the CE directives.

PRELIMINARY EXAMINATION

Remove the instrument from the packing material and examine it carefully. If any damage has occurred during shipment, immediately notify your Dealer or the nearest Hanna Customer Service Center.
Each meter is supplied with:

- **HI 73127** pH electrode
- **HI 73128** Electrode removal tool
- 4 x 1.5V batteries

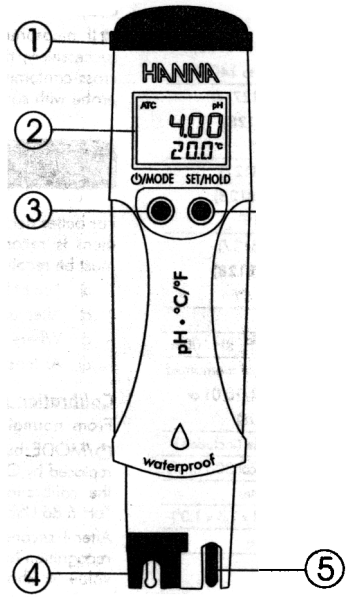
Note: Conserve all packing material until the instrument has been observed to function correctly. Any defective item must be returned in its original packing.

US DESIGN PATENT
D462,024

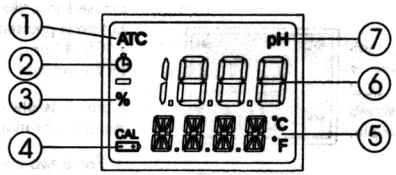
GENERAL DESCRIPTION

HI 98127 and **HI 98128** are waterproof pH and temperature meters. The housing has been completely sealed against humidity and designed to float.
All pH readings are automatically temperature compensated (ATC), and temperature values can be displayed in °C or °F units.
The meters can be calibrated at one or two points with auto-buffer recognition and against five memorized buffer values.
Measurements are highly accurate with a unique stability indicator right on the LCD.
These meters are also provided with battery level indication at start-up, and with a low battery symbol which warns the user when the batteries need to be replaced. In addition the Battery Error Prevention System (BEPS) avoids erroneous reading caused by low voltage level by turning the meter off.
The **HI 73127** pH electrode, supplied with the meters, is interchangeable and can be easily replaced.
The stainless steel encapsulated temperature sensor facilitates faster and more accurate temperature measurement and compensation.

FUNCTIONAL DESCRIPTION



1. Battery compartment
2. Liquid Crystal Display (LCD)
3. ON/OFF/MODE button
4. **HI 73127** pH electrode
5. Temperature sensor
6. SET/HOLD button



1. Automatic temperature compensation indicator
2. Stability indicator
3. Battery life percentage indicator
4. Low battery indicator
5. Secondary display
6. Primary display
7. Measuring unit for primary display

CE DECLARATION OF CONFORMITY

HANNA instruments

CE

DECLARATION OF CONFORMITY

We

Hanna Instruments Italia Srl
via E.Fermi, 10
35030 Sarmeola di Rubano - PD
ITALY

herewith certify that the pH & temperature meters

HI 98127 and HI 98128

have been tested and found to be in compliance with EMC Directive 89/336/EEC and Low Voltage Directive 73/23/EEC according to the following applicable normatives:

EN 50082-1: Electromagnetic Compatibility - Generic Immunity Standard
IEC 61000-4-2 Electrostatic Discharge
IEC 61000-4-3 RF Radiated

EN 50081-1: Electromagnetic Compatibility - Generic Emission Standard
EN 55022 Radiated, Class B

EN61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use

Date of Issue: 13.02.2002

A.Marullo - Technical Director
On behalf of
Hanna Instruments S.r.l.

Recommendations for Users
Before using this product, make sure that it is entirely suitable for the environment in which it is used.
The glass bulb at the end of the electrode is sensitive to electrostatic discharges. Avoid touching the glass bulb at all times.
Any variation introduced by the user to the supplied equipment may degrade the instrument's EMC performance.
To avoid electrical shock, do not use this instrument when voltages at the measurement surface exceed 24 VAC or 60 VDC. To avoid damages or burns, do not perform any measurement in microwave ovens.

ACCESSORIES

HI 73127	Replaceable pH electrode
HI 73128	Electrode removal tool
HI 70004P	pH 4.01 solution, 20 mL sachet (25 pcs)
HI 70006P	pH 6.86 solution, 20 mL sachet (25 pcs)
HI 70007P	pH 7.01 solution, 20 mL sachet (25 pcs)
HI 70009P	pH 9.18 solution, 20 mL sachet (25 pcs)
HI 70010P	pH 10.01 solution, 20 mL sachet (25 pcs)
HI 77400P	pH 4 & 7 solutions, 20 mL sachet (5 each)
HI 7004M	pH 4.01 solution, 230 mL bottle
HI 7006M	pH 6.86 solution, 230 mL bottle
HI 7007M	pH 7.01 solution, 230 mL bottle
HI 7009M	pH 9.18 solution, 230 mL bottle
HI 7010M	pH 10.01 solution, 230 mL bottle
HI 7061M	Electrode cleaning solution, 230 mL bottle
HI 70300M	Electrode storage solution, 230 mL bottle

ISTR98127R4 03/03

SPECIFICATIONS

Range	pH:	-2.0 to 16.0 pH (HI 98127)
		-2.00 to 16.00 pH (HI 98128)
	Temp:	-5.0 to 60.0°C / 23.0 to 140.0°F
Resolution	pH:	0.1 pH (HI 98127)
		0.01 pH (HI 98128)
	Temp:	0.1°C / 0.1°F
Accuracy (@20°C/68°F)	pH:	±0.1 pH (HI 98127)
		±0.05 pH (HI 98128)
	Temp:	±0.5°C / ±1°F
Typical EMC Deviation	pH:	±0.1 pH (HI 98127)
		±0.02 pH (HI 98128)
	Temp:	±0.3°C / ±0.6°F
Temp. Compensation		Automatic
Environment		-5 to 50°C (23 to 122°F); RH 100%
Calibration		1 or 2 points with 2 sets of memorized buffers (pH 4.01/7.01/10.01 or 4.01/6.86/9.18)
Electrode		HI 73127 pH electrode (included)
Battery Type/Life		4 x 1.5V with BEPS/typical 300 hours
Auto-off		After 8 minutes
Dimensions		163 x 40 x 26 mm (6.4 x 1.6 x 1.0")
Weight		85 g (3.0 oz)

OPERATIONAL GUIDE

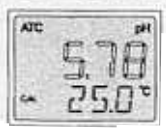
To turn the meter on and check the battery status

Press and hold the ⏻/MODE button until the LCD lights up. All the used segments on the LCD will be visible for 1 seconds (or as long as the button is pressed), followed by the percent indication of the remaining battery life (E.g. % 100 BATT).

Taking measurements

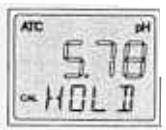
Submerge the electrode in the solution to be tested while stirring it gently. The measurements should be taken when the stability symbol ⏲ on the top left of the LCD disappears.

The pH value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.



To freeze the display

While in measurement mode, press the SET/HOLD button. HOLD appears on the secondary display and the reading will be frozen on the LCD (E.g. pH 5.78 HOLD).



Press any button to return to normal mode.

To turn the meter off

While in normal mode, press the ⏻/MODE button. OFF will appear on the secondary display. Release the button.

Notes:

- Before taking any measurements make sure the meter has been calibrated (CAL tag present on the LCD).
- If measurements are taken in different samples successively, rinse the probe thoroughly to eliminate cross-contamination; and after cleaning, rinse the probe with some of the sample to be measured.

CALIBRATION

For better accuracy, frequent calibration of the instrument is recommended. In addition, the instrument must be recalibrated whenever:

a) The pH electrode is replaced.
b) After testing aggressive chemicals.
c) Where high accuracy is required.
d) At least once a month.

Calibration procedure

From normal measuring mode, press and hold the ⏻/MODE button until OFF on the secondary LCD is replaced by CAL. Release the button. The LCD enters the calibration mode displaying "pH 7.01 USE" (or "pH 6.86 USE" if the NIST buffer set was selected).

After 1 second the meter activates the automatic buffer recognition feature. If a valid buffer is detected then its value is shown on the primary display and REC appears on the secondary LCD. If no valid buffer is detected, the meter keeps the USE indication active for 12 seconds, and then it replaces it with WRNG, indicating the sample being measured is not a valid buffer.

- For a *single-point calibration* with buffers pH 4.01, 9.18 or 10.01, the meter automatically accepts the calibration when the reading is stable; the meter displays the accepted buffer, with the message "OK 1". After 1 second the meter automatically returns to the normal measuring mode.

If a single-point calibration with buffer pH 7.01 (or pH 6.86) is desired, then after the calibration point has been accepted the ⏻/MODE button must be pressed in order to return to normal mode. After the button is pressed, the meter shows "7.01" (or "6.86") - "OK 1" and, after 1 second, it automatically returns to the normal measuring mode.

Note: It is always recommended to carry out a two-point calibration for better accuracy.

- For a *two-point calibration*, place the electrode in pH 7.01 (or pH 6.86) buffer. After the first calibration point has been accepted, the "pH 4.01 USE" message appears. The message is held for 12 seconds, unless a valid buffer is recognized. If no valid buffer is recognized, then the WRNG message is shown. If a valid buffer (pH 4.01, pH 10.01, or pH 9.18) is detected, then the meter completes the calibration procedure. When the buffer is accepted, the LCD shows the accepted value with the "OK 2" message, and then the meter returns to the normal measuring mode.

Note: When the calibration procedure is completed, the CAL tag is turned on.

To quit calibration and to reset to the default values

- After entering the calibration mode and before the first point is accepted, it is possible to quit the procedure and return to the last calibration data by pressing the ⏻/MODE button. The secondary LCD displays "ESC" for 1 second and the meter returns to the normal measuring mode.
- To reset to the default values and clear a previous calibration, press the SET/HOLD button after entering the calibration mode and before the first point is accepted. The secondary LCD displays "CLR" for 1 second, the meter resets to the default calibration and the CAL tag on the LCD disappears.

SETUP

Setup mode allows the selection of temperature unit and pH buffer set.

To enter the Setup mode, press the ⏻/MODE button until CAL on the secondary display is replaced by TEMP and the current temperature unit (E.g. TEMP °C). Then:

- *for °C/°F selection*: Use the SET/HOLD button. After the temperature unit has been selected, press the ⏻/MODE button to enter the buffer set selection mode; press the ⏻/MODE button twice to return to the normal measuring mode.
- *to change the calibration buffer set*: After setting the temperature unit, the meter will show the current buffer set: "pH 7.01 BUFF" (for 4.01/7.01/10.01) or "pH 6.86 BUFF" (for NIST 4.01/6.86/9.18).

Change the set with the SET/HOLD button, then press ⏻/MODE to return to normal measuring mode.

pH ELECTRODE MAINTENANCE

- When not in use, rinse the electrode with water to minimize contamination and store it with a few drops of **HI 70300** storage solution in the protective cap. DO NOT USE DISTILLED OR DEIONIZED WATER FOR STORAGE PURPOSES.

- If the electrode has been left dry, soak in storage solution for at least one hour to reactivate it.

- To prolong the life of the pH electrode, it is recommended to clean it monthly by immersing it in the **HI 7061** cleaning solution for half an hour. Afterwards, rinse it thoroughly with tap water and recalibrate the meter.

- The pH electrode can be easily replaced by using the supplied tool (**HI 73128**). Insert the tool into the electrode cavity as shown below.

Rotate the electrode counterclockwise.

Pull the electrode out by using the other side of the tool.

Insert a new pH electrode following the above instructions in reverse order.

The meter displays the remaining battery percentage every time it is switched on. When the battery level is below 5%, the symbol on the bottom left of the LCD lights up to indicate a low battery condition. The batteries should be replaced soon. If the battery level is low enough to cause erroneous readings, the meter shows "0%" and the Battery Error Prevention System (BEPS) will automatically turn the meter off.

To change the batteries, remove the 4 screws located on the top of the meter.

Once the top has been removed, carefully replace the 4 batteries located in the compartment while paying attention to their polarity.

Replace the top, making sure that the gasket is properly seated in place, and tighten the screws to ensure a watertight seal.

APPENDIX J

Chemserve Laboratory Materials

317 Elm Street
Milford NH 03055
Tel (603) 673-5440
Fax (603) 673-0366

QUALITY SYSTEMS MANUAL
FOR

CHEMSERVE LABORATORY
317 ELM STREET
MILFORD, NEW HAMPSHIRE 03055
1-603-673-5440

Federal Tax ID#. 020397283

Laboratory Directory — **Date** March 9, 2005

Quality Assurance — **Date** 3/9/05

This Quality Systems Manual is applicable to the Organics, Inorganics, Microbiology and Field Services Departments.

Revision Date:March 2005

ChemServe ENVIRONMENTAL ANALYSTS

317 Elm Street
Milford NH 03055
Tel (603) 673-5440
Fax (603) 673-0366

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ChemServe ENVIRONMENTAL ANALYSTS
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Attachments

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Attachment #3	Listing of Laboratory Equipment and Reference Materials
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Attachment #5	Field Sampling Equipment Sample Container and Preservation Chart Field Sampling SOP list
Attachment #6	List of Analytical Tests, Method References and Reporting Limits
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Attachment #8	Precision and Accuracy Form

Current State Certifications

1.0 Quality Policy Statement

Chemserve sets extremely high standards for quality analytical services. It is our philosophy that quality results are the most important service a laboratory can provide. We take great measures to assure our customers that we are providing the highest quality analysis available.

To ensure proper QA/QC measures are followed, in the laboratory and in the field, Chemserve has developed a complete quality assurance program. This program incorporates strict procedures set forth by state and federal agencies, as well as further protocols required by industry and consulting firms. Because accurate results must not be compromised, we take the time to ensure the quality objectives for all data are met with every analysis.

Because the management and staff at Chemserve are committed to providing quality data for all clients, the analysts are aware that at no time should they be made to feel undue pressure or obligation to analyze or process more samples in a given work shift then they can accomplish providing acceptable data and quality control samples.

We encourage our employees to actively participate in improving this program and to develop and advance our program with changing needs and regulations. Chemserve continually responds to client needs, from state, federal and local regulations.

1.1 Ethics Statement

Chemserve has a zero tolerance for unethical activities, scientific misconduct, and intentional lack of compliance with required procedures and policies.

Employees shall at all times conduct themselves and the business of Chemserve in an honest and ethical manner. Employees that are aware of unethical behavior or practices are encouraged to take action, either at the bench level (direct discussions with the employee) or by informing management.

Compliance with this policy shall be strictly enforced with individual disciplinary action or termination.

2.0 Organizational and Management Structure

2.1 Organizational Chart

See Attachment 1

2.2 Management Responsibilities

2.2.1 Responsibilities of Laboratory Management

a) The laboratory management ensures the supervision of all personnel employed by the laboratory.

b) The Laboratory management is responsible for ensuring the quality of data produced by the laboratory. This is done by ensuring employee compliance with all EPA approved methods, NH-ELAP policies and company established SOP's.

c) Laboratory management will be responsible for training and keeping personnel up to date on laboratory procedures, operation of instrumentation and laboratory support equipment.

d) Data validation is performed by the laboratory management or their designees.

2.2.2 Quality Assurance Officer (QAO)

a) The QAO is the person responsible for the laboratory's quality assurance program and it's implementation. The quality assurance program must ensure compliance with state, federal, and local regulations and certifying agencies.

b) The QAO reviews laboratory data and conducts annual internal laboratory audits. The QAO ensures any corrective action arising from internal audits are implemented in a timely manner.

c) The QAO is free from internal and external influences when evaluating data and conducting audits.

d) The QAO have training or experience, or both in quality assurance/quality control procedures and is knowledgeable of the approved analytical methods and quality assurance program requirements.

e) The QAO has direct access to the laboratory management.

f) All reports are reviewed by the QAO for accuracy and completeness before release to the customer.

g) Investigates customer concerns regarding data and implements corrective action if needed.

2.3 Job Description of Staff Positions

SAMPLE RECEIVING
Responsible for the receipt and storage of all incoming samples
Responsible for following the Sample Receipt SOP.
Ensure Chain of Custody is filled out completely and relinquished by person delivering samples.
Responsible for notation of any deviations of the sample, including but not limited to holding time issues, preservation or container issues.

CUSTOMER SERVICE
Responsible for responding to customer requests and complaints in a timely manner.
Responsible for obtaining all pertinent information regarding sampling, analysis, permits etc. so work can proceed in a smooth fashion.
Track the due dates of reports to ensure proper turnaround time and inform clients when dates will be missed.
Notify customers of any deviations that occurred during sample receipt.
Responsible for notifying the lab of any changes.

LABORATORY ANALYSTS
Responsible for performing analysis according to EPA, State and NH-ELAP approved methods and company established SOP's.
Following all QA/QC procedures as outlined in the QA manual.
Documentation of all analysis, calibration and QC data in bench logs.
Troubleshoot out of compliance instruments and analysis. This includes documentation of all instrument maintenance and implementation of corrective action.
Following all safety procedures as outlined in the Chemserve Chemical Hygiene Plan.

FIELD SERVICES
Work closely with the Customer Service Manager on a daily basis to insure "on time" field services.
Collect samples according to EPA, state and local regulations and company SOP's.
Responsible for the maintenance and cleaning of all sampling equipment and vehicles.
Documentation of all field activities and any deviations.
Maintain samples according to regulations during transportation.

2.4 Personnel Qualifications

Attachment #2

2.5 Identification of Approved Signatories

The following individuals are authorized to sign laboratory reports

Jay Chrystal – President is authorized for signing his name and for the QAO if unavailable.

Ellen Abrams – QA Manager is authorized for signing her name and for Jay Chrystal if he is unavailable.

Paul Fyfe – Director of Operations is authorized to sign for Ellen Abrams if she is unavailable.

Jacqui Fillmore – Office Manager is authorized to sign Well Water reports for QA Manager.

2.6 Quote, Contracts and Bid Review

All requests for quotes, contracts and bids will be reviewed by the Customer Service Representative, Lab Director and if necessary the Operation Manager and QA Manager. This review will be done to see if the lab is certified to perform the requested analysis. To see if there is enough capacity in the lab to perform the work. Also if special or additional supplies are needed, they can be accounted for at this time.

3.0 Procedures for Record Management

The laboratory has implemented a record management system which allows the historical reconstruction of all laboratory activities. A record for each environmental analysis will be kept by the laboratory for not less than 10 years. The following records will be maintained by the laboratory:

a) Personnel Records

b) Equipment and reference materials:
   1) The name of the item
   2) The manufacture's name, identification and serial number
   3) Date received and date placed in service
   4) Condition when placed in service (new, used, re-conditioned)
   5) Current location
   6) Location of manufacturer's instruction manual, when available
   7) Details of maintenance
   8) Calibrations with acceptance criteria.

c) For reagents and reference materials, the laboratory will retain the manufacturer's statement of purity and traceability (if applicable). The date of receipt, storage conditions, date opened (when applicable), and name of analyst.

d) Preparation of stock and working stock solutions. The laboratory will maintain a preparation log which will include traceability to purchase reagent or reference material, date of preparation, expiration date and name of analyst.

e) Sample collection and handling. The laboratory will maintain sufficient records to demonstrate samples were properly collected, handled and preserved. This information can be found on the Chain of Custody. This will include:

   1) Date, place, and time of sampling. The name of the person who collected the sample.
   2) Laboratory sample identification and field identification
   3) Signature of person responsible for receiving the samples.
   4) Date and time of sample receipt
   5) Analysis or analytical method requested
   6) Laboratory name or place of analysis
   7) Sample collection forms
   8) All information regarding sample integrity and sample acceptance as defined under sample collection, preservation, holding times and handling of this document.

f) Analytical procedures. This will include:

1) Sample identification with date and time of sample preparation and analysis. Initials or signature of the analyst involved in preparation of samples and the analyst involved in the analysis of the samples.

2) The analytical method used.

3) Results of the analysis and the raw data generated. This will include calibrations with acceptance criteria and identification of the instrument.

4) Results of quality control and acceptance criteria.

5) All calculations.

6) Validation of data and initial or signature of the data reviewer.

g) Internal audits and Quality Assurance Program reviews. All reviews, audits, audit findings and corrective action taken will be documented by the laboratory.

h) Proficiency testing. The laboratory will maintain all information resulting from the analysis of proficiency testing samples. This will include a copy of the proficiency testing study forms, and documentation of investigations and corrective actions for failed studies.

i) All electronic hardware and software to reconstruct the analytical data will be available at the laboratory.

j) Records of record storage and access of these records.

k) Copies of final reports and amendments.

l) Copies of historical QA documents

m) Correspondence relating to laboratory activities for a specific project.

All data not generated electronically, will be recorded in a legible manner using permanent ink.

All corrections to records will be made by crossing the error with a single line, the date of the correction will be noted and the individual making the correction will initial or sign the record.

Records will be stored securely and safely to prevent loss or potential tampering.

Computer and electronic systems used by the laboratory for recording, processing, reporting, storage or retrieval of data will comply with sections 8.1 through 8.11 of EPA document 2185-Good Automated Laboratory Practices (1995).

3.1 Document Control

a) Document control is an important process for the management of laboratory documents and to ensure the laboratory staff have knowledge of and access to the most current laboratory adopted procedures.

All documents will follow an uniformed document control procedure.

Each document will include a title, a revision number, date of creation, page number and total number of pages. This will be in the header of each documents.

Ex. Procedures for the Determination of XX
Rev. No.:GN001.01
Date: 12/09/99
Page 1 of 5

All QA documents will be approved and initial by the QA manager and the Dept. manager.

Documents that will be controlled are as follows:

- SOP's
- Help Notes
- Policy Notes
- QA Manual
- Chemical Hygiene Plan

Worksheets, forms and logbooks will be designed to include all information pertinent to the analysis or task performed. Each worksheet, form and logbook will include a unique identifier. Worksheets and forms will have a revision number and or date.

3.2 Record Retrieval

In the event the laboratory is sold or acquired producing new ownership, all records, files, computer tapes, computer backups, written material, and all other forms of customer records, will be transferred as part of the transaction.

In the event that the laboratory ceases to exist, prior to shutting down, all records, files, computer tapes, computer backups, written material and all other forms of customer records will be stored at a commercial storage facility for ten years. The agreement with the storage facility will have specific instructions on access restrictions and contacts. These contracts will be updated when necessary.

4.0 Laboratory Equipment, Reagents, Supplies and Reference Materials

All equipment, reagents, supplies and reference materials necessary for analyses are kept on hand for the specific analysis for which Chemserve is accredited.

4.1 General

a) Laboratory Equipment

1) All equipment is properly maintained. Procedures for maintenance of equipment are documented in method SOP's.

2) Any defective equipment or parts will be removed form service and labeled until repaired. Equipment or parts will not be put back in service until the laboratory demonstrates that it is functioning correctly. Any maintenance performed on instrumentation will be documented in maintenance logs.

3) Calibration records are maintained for all measuring equipment.

b) Laboratory Support Equipment

All laboratory support equipment will be calibrated or verified, or both, before being put into service, and on a continuing basis. The procedures for the calibration and verification of the laboratory support equipment are found in SOP's.

c) Reagents and Supplies

1) Glassware will be properly cleaned and maintained as specified in the SOP. Any cleaning or maintenance requirements specified in the approved test procedure will be followed. Special cleaning instructions will be stated in the SOP.

2) Analytical reagent grade materials, if available, will be used by the laboratory.

3) The laboratory will not use prepared reagents, standards, or purchased chemicals outside the expiration date of the material.

4) All stock and standard solution containers will be labeled with content, preparation date, concentration and initials of the analyst preparing the solution.

5) Compressed gases will meet the requirements specified in the approved method.

6) For the preparation of reagents, standards and rinsing glassware, the laboratory uses laboratory grade DI water.

d) Reference materials

1) To ensure accurate and precise measurements, the laboratory uses reference materials that are traceable to NIST.

2) The laboratory will keep the calibration certificates of reference materials to demonstrate the traceability to NIST.

3) Reference materials (such as class S weights or equivalent, or thermometers) will go through periodic re-certifications that are traceable to NIST.

4) The original containers will be labeled with the date opened and the expiration date (when applicable).

4.2 Listing of Laboratory Equipment and Reference Materials

See Attachment 3

4.3 Description of Facilities and Services Used by the Laboratory

a) Description and Floor plan of Laboratory

Attachment #4

b) General

1) The laboratory will be kept clean. Attention is given to good housekeeping at all times.

2) The laboratory has adequate lights and ventilation. Laboratory temperature and humidity will be maintained within adequate range for the analysis performed at the laboratory and for the proper operation of instrumentation. There are 2 exhaust hoods in the extraction laboratory, one is used for the extraction laboratory for the extraction of semi-volatile samples. The other hood is used for inorganic analysis.

3) The laboratory has 4000 ft of work space which is considered sufficient for conducting all laboratory activities.

4) The laboratory has 6000 ft of storage space which is considered sufficient to contain and store all needed supplies, reagents, and equipment.

5) Each area of the laboratory has secondary waste containers that are checked on a weekly basis and emptied on an as needed basis. These secondary waste containers are emptied into larger drums in the waste storage area of the warehouse. All Biological wastes are autoclaved for a minimum of 30 minutes at 245°F. This waste is then disposed of in the dumpster. Samples are treated with Clorox and disposed down the drain.

6) The laboratory is designed and activities are conducted so sample contamination is avoided. Samples for volatile analysis are stored in a separate refrigerator to avoid contamination.

7) Due to the size of the laboratory access to the analytical and sample storage areas are available to all laboratory personnel.

5.0 Procedures for Dealing with Complaints

Calls from customers may be taken by all personnel in the front office. All information is recorded on a Quality Control Check Request Form. These forms are forwarded to the QAO. The QAO investigates all client concerns. Based on what is found a client call will be made to inform the client of the outcome. Resulting action from a customer complaint can vary from a reissued report, data reanalysis, re-sampling or modification to laboratory procedures. A record of this information is kept by the QAO.

If the client is not satisfied with the response the laboratory director will be notified.

6.0 Procedures for Protecting Client Confidentiality and Proprietary Rights

6.1 Analytical reports will only be mailed to and discussed with the customer indicated on the report or customer authorized individuals. In the event that the data must be discussed with someone other than the customer written authorization from the customer must be received before any discussion takes place.

6.2 Customer information will be blacked out on any reports used as examples.

6.3 Raw data requested by the customer will only contain the data pertinent to their samples. In the case of logbook data, all identifying information from other clients will be blacked out.

6.4 Building security is maintained by having visitors received at the reception area and accompanied into the building. All entrances are locked during non-business hours.

7.0 Procedures for Personnel Training

a) Before conducting any analysis, each analyst will receive training by another analyst or supervisor who has completed training. An analyst in training will be supervised by an experienced individual. All data produced by the trainee will be reviewed and signed off by an experienced analyst. All required reading such as SOP's, Help Notes etc. will require a "Read and sign" form. This form will be kept on file by the QAO as proof of training. All analysts will also be required to do a Precision and Accuracy study if required by the method.

b) In addition to in-house training, additional training may be provided to the analyst in the form of education courses and professional seminars.

c) Analyst training and performance will be considered complete after the analyst has produced a successful initial demonstration of method performance for the analysis for which they are responsible. All training will be documented and kept on file. At a minimum documentation will include the name of the analyst, the reference method/SOP, the dates of training, the person providing training, initial demonstration of method performance(if appropriate) and PT results (if appropriate). To document the training, Chemserve will use the training form for each analytical procedure.

8.0 Sampling Procedures

To ensure the quality of environmental analysis, the laboratory will ensure each sample is properly collected, handled, and preserved. Procedures are in place for the collection of the samples, sample handling, preservation and holding time and for sample acceptance criteria.

8.1 Sampling Equipment, Containers, Preservation and Holding Times

a) Samples are collected using the following equipment: See Attachment #5.

b) A sample collection form shall be completed for each sampling event. This form shall contain sampling location, date and time of collection, collector's name, method of preservation and special remarks concerning the sample.

8.2 Sampling Collection Procedures

See Field Sampling SOP's

8.3 Sample Handling Procedures Including Sub-sampling and Sample Acceptance Criteria

a) Each sample is uniquely identified from collection through disposal.

1) A completed chain of custody (COC) accompanies samples. Each section of the COC must be checked for completeness. Any deviations with sample containers, preservation, holding times or sample integrity will be noted on the COC during sample receipt.

2) Each COC (job) is assigned a unique number, with each sample being assigned a unique number. This identification is used to track the sample from receipt, storage, analysis, reporting and disposal.

Example 99020131-01

The first two digits refer to the year of receipt, the second two digits refer to the month of receipt and the last four digits are in the order the jobs are logged into the LIMS system. The two digits after the hyphen indicate the sample number. These digits are assigned sequentially on the COC.

Labels for sample containers are printed using a laser jet printer. The labels are chemical and water resistant. If a sample container is coated with product such that a label will not stick to it, the sample will be put in a ziplock bag and the label will go on the bag. The client sample label contains the COC number which can be used to trace the sample in the event the other label becomes unreadable.

3) The client will be notified of any sample deviations. It will be the client's decision to continue analysis. This should be done in writing.

4) A Change Order form will be filled out and attached to the COC if the client requests any additional analysis or deletes any analysis.

b) After sample collection and transportation to the facility, the laboratory will check the integrity of the sample by checking the following items:

1) Leakage or breakage

2) Completeness of sample collection forms.

3) Correct sample Identification

4) Use of appropriate sample containers, adequate volume, preservation and holding time as required by section 8.1.

5) Temperature of samples requiring thermal preservation will be checked and recorded.

6) Chemical preservation will be checked if appropriate. The pH of VOA samples will be checked at analysis. Results will be recorded on the COC or in the VOA logbook.

8.4 Storage of Samples in the Laboratory

a) The laboratory will store samples, sub-samples, extracts and digestates according to the specified conditions in the approved methodology. All samples, sub-samples, extracts and digestates will be protected from all potential sources of contamination. Volatile samples will be stored separately from all other samples. Each method SOP indicates storage temperature and holding time.

In general all samples and extracts are stored at 4±2°C. All digestates are stored at room temperature.

8.5 Sample Disposal

All samples are stored in the refrigerators for a minimum of 30 days after the report has been issued. Extracts are stored for 40 days or longer. Digestates are stored for a minimum of 30 days also.

Samples that need to be held for longer than the standard amount of time shall be boxed and labeled "DO NOT DISPOSE UNTIL XXXX DATE". Samples shall be kept refrigerated if possible.

8.6 Forwarding Samples to another Laboratory for Analysis

Samples will be sent to another laboratory for analysis according to the Sub-Contracting SOP.

When the laboratory forwards collected samples to another laboratory for analysis, a Chemserve COC will be used.

The Laboratory receiving the samples must be NELAC certified for the analysis being requested, unless otherwise noted by the client.

9.0 Calibration Procedures of Analytical Instrumentation and Frequency

For calibration of analytical instrumentation, the laboratory will use NIST traceable standards (when available).

Calibration procedures are established for all applicable tests. These procedures are detailed in the SOP for the analysis. The calibration requirements of the USEPA approved procedures are followed by the laboratory.

a) ICP INDUCTIVELY COUPLED PLASMA (ICP)/ ATOMIC ABSORPTION SPECTROPHOTOMETER

1) At the beginning of each day, and when optical characteristics change, the instrument is optimized in accordance with manufacturer's specifications.

2) The calibration curve consists of a blank and a minimum of three standards for each analysis. The validity of the curve is established by running an appropriate Independent Check Known and a standard at the lowest detection limit of the metal being analyzed.

3) The instrument shall analyze all standards and samples as 3 replicates. The mean shall be reported.

4) Each instrument calibration shall contain the following: a blank, an independent check known, A PQL check, and an interference check standard. These will be analyzed at the beginning of the run. Each sample run shall contain a prep blank, a prep blank matrix spike, a matrix, matrix spike duplicate for every digestion batch of 20 unknowns. A continuing calibration verification and a blank every ten unknowns and at the end of the run. The end CCV will be at a different concentration than the starting CCV.

5) The relative percent difference between duplicate results shall be within 20%.

6) The percent recoveries for each matrix spike will be (80-120%) and LCS, shall be within 85-115%. This limit does not apply if the sample concentration is four or more times higher than the spike concentration a stated in "Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses," 1988.

b) COLD VAPOR MERCURY ANALYSIS

1) Prior to calibration and analysis, all blanks, calibration standards, knowns and samples shall be digested.

2) The calibration curve shall contain a blank and four standards. An appropriate independent check known will be used to establish the validity of the curve.

3) The instrument shall analyze all standards and samples as 3 replicates. The mean shall be reported.

4) Matrix Spike and matrix spike duplicate samples shall be analyzed every 20 samples (5% frequency). Prep blanks and check knowns shall be analyzed every 10 samples (10% frequency).

5) TCLP samples shall be analyzed with a method blank from the extraction process as well as a tumbled duplicate and matrix spike.

6) The relative percent difference (%RPD) between duplicate results shall be ±20%.

7) See Instrument run log for LCS and MS limits.

c) **ION CHROMATOGRAPHY**

1) The calibration curve consists of a blank and a minimum of three standards for each ion for a curve covering 1 order of magnitude. If the curve covers 2 orders of magnitude 5 standards are needed. The validity of the curve is established by running an appropriate independent check known and the lowest detection limit of the ions being analyzed.

2) The calibration curve is verified each day of analysis and when the anion eluent is changed. A new curve is prepared when the results differ by more than 10% or every three months, which ever is more frequent.

3) When a new curve is not being performed, the existing curve is verified by running a reagent blank and a CCV. The end of the run sequence will have a CCV that is of a different concentration than the starting CCV.

4) Each run contains the following: a blank and CCV at the beginning and at the end, a CCV after every ten samples, a MS/MSD pair are run every ten samples or less.

5) The relative percent difference between duplicate results shall be within ±25%.

6) The percent recoveries for matrix spike shall be within 90-110%. This limit does not apply if the sample concentration is four or more times higher than the spike concentration as stated in "Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses", 1988.

d) ION SELECTIVE ELECTRODE ANALYSIS

1) The pH probe shall be calibrated daily with pH buffers 4,and 7. The slope must be >98%. The validity of the calibration is check by analyzing a check known. The check known will be within ±0.2 pH units of the true value.

2) All results are logged in a logbook containing the following information: analyst, analyte, check knowns used with 95% confidence intervals, and the date the analyses were performed and lot numbers of chemicals used for knowns.

e) SPECTROPHOTOMETRIC METHODS

1) Calibrations shall consist of five points validated with an appropriate check known. Curves shall be entered into a Linear Regression Excell Spreadsheet to establish Beer's Law relationships and linearity. The correlation co-efficient must be ≥0.995.

2) The calibration curve must be validated daily with a blank and a standard (CCV) prepared from the same stock as the calibration curve. The end of the sequence must be finished with a CCV of a different concentration than the starting CCV. The limits are 80-120% unless otherwise specified in the SOP. The Log book must contain the calibration curve date, wavelength, cell size and analysts initials.

3) A reagent blank is analyzed with every set of samples. A prep blank and a point on the curve are carried through each batch of digestions or extractions.

4) Quality control consists of analyzing a check known, blank, MS/MSD pair if possible otherwise a duplicate every batch of twenty samples or less.

5) See Analysis Logbook cover for %RPD and % recovery limits for the LCS, MS/MSD and duplicate samples.

6) All results are logged in a log book containing the following information: analyst, date extracted, date analyzed, wavelength used, check knowns used with 95% confidence intervals, standards used, and the lot number of chemicals used for samples.

f) TITRIMETRIC ANALYSES

1) On the day of analysis, a check known is analyzed to confirm the normality of the titrant.

2) The titrant is normalized against a primary standard.

3) For those analyses that require distillation or digestion, a distillation/digestion blank is analyzed to demonstrate that the analysis is free from cross contamination. A distillation/digestion blank and an LCS must be prepared with each batch (24hrs or 20 samples).

4) Quality control consists of analyzing a check known, blank, MS/MSD if possible otherwise a duplicate every batch of twenty samples or less. The Matrix spike are prepared prior to distillation or digestion.

5) See Analysis Logbook cover for %RPD and % recovery limits for the LCS, MS/MSD and duplicate samples. The check known must be within 95% of the true value.

6) All results are recorded in the appropriate logbook with the following information: analyst, date distilled or digested, date analyzed, standards used and ID, spikes, check known, sample ID and results.

g) BIOLOGICAL OXYGEN DEMAND

1) The dissolved oxygen meter is calibrated against an oxygen saturated water blank before beginning the analysis.

2) A glucose-glutamic known, matrix spike, duplicate, seeded and non-seeded blanks are analyzed with each set on analyses.

3) All results are recording in a logbook including the following information: date, temperature, barometric pressure, sample ID, volume used, dilution factor, initial and Final D.O. and calibration parameter.

4) All samples shall be analyzed with 4-8 dilutions.

5) Samples that have never been analyzed shall be spiked and evaluated for potential interferences.

h) CONDUCTIVITY ANALYSIS

1) On the day of analysis, the instrument is calibrated to an appropriate range with a standard. The accuracy of the calibration shall be check against a second standard.

2) All results are recorded in the logbook including the following information: analyst, Standard ID calculations, check known used with 95% confidence limits, samples analyzed and the date of analysis.

3) A blank, duplicate and calibration check shall be analyzed every 20 samples.

i) GRAVIMETRIC ANALYSIS

1) The analyst must verify the balance before and after use, using a 100g weight. The balance will be checked with a minimum of 3 Class S weights on a daily basis.

2) Quality control consists of analyzing a check known, blank, MS/MSD if possible, otherwise a duplicate every batch of twenty samples or less. The % recovery is expected to be 78-114%

3) All results are logged in the appropriate logbook with the following information: analyst, date extracted, date analyzed, volume of sample used, check known, sample ID and initial and final weight.

j) VOLATILE GC/MS 524, 624, 8260, VPH

1) Prior to the analysis of samples or blanks the instrument must meet the following Ion abundance pattern criteria for daily tuning. All ion abundances must be normalized to m/z 95. Meeting this performance check ensures mass resolution, identification and sensitivity. Having met these criteria a 12hour window for data collection exist.

4-Bromofluorobenzene

m/z	Ion Abundance Criteria
50	15-40% of mass 95
75	30-60% of mass 95
95	Base peak 100% relative abundance
96	5-9% of mass 95
173	<2% of mass 174
174	50-100% of mass 95
175	5-9% of mass 174
176	>95% by <101% of mass 174
177	5-9% of mass 176

2) Initial Calibration

When the BFB criteria has been satisfied the system is initially calibrated with a minimum of five standards. The lowest standard is the method reporting limit. Initial calibration demonstrates the instruments ability for producing a linear curve from which all quantitations will be performed. Evaluation criteria for it's magnitude and stability are as follows, the minimum acceptable average RF for the SPCC compounds are

Chloromethane	0.10
1,1-Dichloroethane	0.10
Bromoform	0.10
Chlorobenzene	0.30
1,1,2,2-tetrachloroethane	0.30

Calibration Check Compounds (CCC's)
The CCC's are used to evaluate the calibration from the standpoint of the integrity of the system. High variability for these compounds indicates system leaks or reactive sites on the column. The CCC compounds are; 1,1-Dichloroethene, Chloroform, 1,2-Dichloropropane, Toluene, Ethylbenzene and Vinyl Chloride.

The %RSD for the CCC compounds must be≤30%. The %RSD for all other target analytes must be ≤15% for method 8260, and ≤20% for 524 and 624..

If the % RSD is >30% for the ccc's, then the system is to reactive for analysis to begin. The system must be repaired and the initial calibration must be repeated. If the %RSD's are acceptable analysis can begin.

Historical data indicates both poor response and erratic behavior for the following compounds. Initial calibration criteria does not apply to the following list of compounds:

Acetone	Acrolein
Acrylonitrile	2-Butanone
2-Hexanone	2-Chloroethyl vinyl ether
4- methyl 2- pentanone	

The standard responses are calculated according to the internal standard method. The instruments initial calibration is evaluated upon the magnitude of the relative response factors of each target compound and system monitoring compound. The calibration is also evaluated on each analytes's %RSD stability across all concentrations. Upon achieving the criteria listed above an independent calibration check is performed. Results should be within ±20%.

3) Continuing Calibration Checks must take place during the course of analysis after a valid calibration curve has been established and or the 12 hr tune has been completed.

a) For method 624 the CCV must be done every 20 samples and at the end of the analytical run. The RF's for each compound must be compared to the initial calibration and be within specific limits.

b) For methods 524 the CCV must be analyzed every 8 hours. The difference between the average RF can not be greater than 30%.

c) For 8260B the CCV must be done every 12 hours. The acceptance criteria is as follows: the SPCC's must meet a minimum 0.050 RF. The CCC's must be within 20% of the initial calibration.

k) SEMI VOLATILE GC/MS 625, 8270, AND EPH

1) Prior to the analysis of samples, standard or blanks the instrument must meet the following Ion abundance pattern criteria for daily tuning. All ion abundances must be normalized to m/z 198 (the nominal base peak) although the ion abundance m/z 442 may be up to 110% of m/z 198. Meeting this performance check ensures mass resolution, identification and sensitivity. Having met these criteria a 12 hour window for data collection exist.

Decafluorotriphenylphosphine

m/z	Ion Abundance Criteria
51	30-60% of mass 198
68	less than 2% of mass 69
69	present
70	less than 2% of mass 69
127	40-60% of mass 198
197	less than 1% of mass 198
198	100% relative abundance
199	5-9% of mass 198
275	10-30% of mass 198
365	greater than 1% of mass 198
441	present but less than mass 443
442	greater than 40% of mass 198
443	17-23% if mass 442

2) Initial Calibration

Upon satisfying DFTPP criteria the system must be calibrated with a minimum of five standards. The lowest standard is the method

reporting limit. Initial calibration demonstrates the instruments ability for producing a linear curve from which all quantitations will be performed. Evaluation criteria for it's magnitude and stability are as follows: The minimum acceptable average RF for these compounds is

Chloromethane	0.10
1,1-Dichloroethane	0.10
Bromoform	0.10
Chlorobenzene	0.30
1,1,2,2-tetrachloroethane	0.30

The CCC's are used to evaluate the calibration from the standpoint of the integrity of the system. High variability for these compounds indicates system leaks or reactive sites on the column. The CCC compounds are; 1,1-Dichloroethene, Chloroform, 1,2-Dichloropropane, Toluene, Ethylbenzene and Vinyl Chloride.

The %RSD for the CCC compounds must be≤30%. The %RSD for all other target analytes must be ≤15%.

Historical data indicates both poor response and erratic behavior for the following compounds.

Hexachlorobutadiene	2,4,6-Tribromophenol
Hexachlorocyclopentadiene	Carbozole
4-Nitrophenol	Benzoic Acid
4,6-Dinitrio-2-methylphenol	Isophorone
Pentachlorophenol	Azobenxene
Benzidene	

3) Continuing Calibration

All analytes must be ≤25% difference of the initial calibration, in addition to satisfying the previously listed RF criteria. Continuing Calibration checks must take place during the course of analysis after a valid calibration curve has been established. The standard solution used for the CCV can be the same as the initial calibration as long as an Independent check has been done to validate the curve. The independent check solution must be from a different source or lot number. If this check is not done, the CCV solution must be from a different source or lot number than the initial calibration solution.

a) 8270 – Continuing calibration must be performed every 12 hours. The RRF from this CCV must be compared to the RRF's from the initial calibration. The relative standard deviation between the two

must be ≤30% for the CCC compounds and 15% for all other compounds. The percent difference between the CCV and the initial calibration must be ≤20% for all target analytes. The SPCC compounds must also meet a minimum response factor of 0.050.

b) 625 – Continuing calibration verification sample must be analyzed on each working day. The CCV must be near the midpoint of the calibration curve. The response must be± 10% of the true value.

If the continuing calibration verification is not within control limits, the source of the problem must be investigated. If necessary a new initial calibration must be prepared.

l) PCB/ PESTICIDE 608, 8081, 8082

1) Initial Calibration

The initial calibration consists of a minimum of five points, the lowest point being the method reporting limit. The remainder of the points should cover the linear range of the instrument. The Pesticide calibration must be analyzed so that there is no co-elution of peaks, Lindane and b-BHC upon one column. The multi component peaks must be analyzed individually. The exception to this is Aroclor 1016-1242 which are combined into one mix.

The response factors are calculated using the external standard method. The instruments initial calibration is evaluated on the basis of the magnitude and stability of the relative response factors of each target compound and system monitoring compounds. The calibration is also evaluated on each analytes's %RSD across the differing concentrations. For 608 the %RSD must be ≤10%. For 8081/8082 the % RSD for each compound must be ≤20%. After the initial calibration is complete and independent verification standard should be analyzed.

2) Continuing Calibration

The initial calibration must be verified every day for all target analytes. This is done by analyzing calibration verification sample at the beginning of each day, after every 20 samples and at the end of the run. The end CCV must be a different concentration that the first CCV. The response or the calculated concentration of each analyte must be within ±15% of the response of the initial calibration for 8081/8082 and ±10% for 608. If the CCV is not within control limits corrective action must be taken.

The resolution of the GC must also be verified each day. A standard containing DDT and Endrin is analyzed. These two compounds breakdown when the injection port liner becomes contaminated. The presence of DDE, DDD, Endrin Ketone, or Endrin indicates breakdown is occurring. If degradation of either DDT or Endrin exceeds 15% corrective action must take place.

m) HERBICIDE 8151A

1) Initial Calibration
The initial calibration consists of a minimum of 5 standards, the lowest standard is the method reporting limit. The rest of the points should cover the working range of the instrument. The response factors are calculated using external standards. The % RSD for the response factors must be ≤20%. After the initial calibration has been analyzed an independent verification sample should be analyzed.

2) Continuing Calibration
The initial calibration must be verified every day for all target analytes. This is done by analyzing a calibration verification sample at the beginning of each day, after every 20 samples and at.the end of the run. The end CCV must be a different concentration that the first CCV. The response or the calculated concentration of each analyte must be within ±15% of the response of the initial calibration. If the CCV is not within control limits corrective action must be taken.

n) EXTRACTABLE PETROLEUM HYDROCARBONS (MADEP EPH)

1) Initial Calibration
See Initial Calibration information for GC/MS 8270.

2) Continuing Calibration
The continuing calibration verification sample must be analyzed after the tune criteria has been met. The RF's for the CCV must fall within 25% of the initial calibrations RF.

o) VOLATILE PETROLEUM HYDROCARBONS (MADEP VPH)

1) Initial Calibration
See Initial Calibration information for GC/MS 8260B.

2) Continuing Calibration
The continuing calibration verification sample must be analyzed after the tune criteria has been met. The RF's for the CCV must fall within 25% of the initial calibrations RF.

9.1 CALIBRATION AND MAINTENANCE OF SUPPORT EQUIPMENT

CALIBRATION AND MAINTENANCE			
INSTRUMENT	ACTIVITY	FREQUENCY	DOCUMENTATION
Balance	1. Clean □ 2. Check alignment 3. Service Contract 4 Calibrate	1. before use 2. before use 3. annual 4. before use	3. Post service date on balance 4. Work sheet/log book
Class S Weights	1. Only use for the intended purpose □ 2. Use plastic forceps to handle □ 3. Keep in case □ 4. Re-calibrate	4. Once every 2 years	4. Keep certificate
Thermometers: □ 1. Glass and electronic □ 2. Dial thermometers	Check at the temperature used, against a reference NIST certified thermometer	□ 1. Annual for glass and electronic □ 2. Quarterly for dial thermometers	Calibration factor and date of calibration on thermometer and work sheet/log book
pH electrometers	Calibration: □ 1. pH buffer aliquot are used only once □ 2. Buffers used for calibration will bracket the pH of the media, reagent, or sample tested.	before use	Log book
pH probe	Maintenance: □ Use manufactures specifications	As needed	Log book

CALIBRATION AND MAINTENANCE			
INSTRUMENT	ACTIVITY	FREQUENCY	DOCUMENTATION
Spectrophotometer.	1. Keep cells clean 2. Service contract. Check wavelength settings with color standards	2. Annual	2. Post service date on balance
Automatic or digital type pipettes	Calibrate for accuracy and precision using reagent water and analytical balance	Quarterly	Logbook
Refrigerators, Freezers, and BOD incubators	1. Thermometers are immersed in liquid to the appropriate immersion line 2. The thermometers are graduated in increments of 0.1 C.	Temperatures are recorded twice each day in use	Work sheet
Autoclave	1. Use a maximum-temperature-registering thermometer. 2. Use spore strips or ampules. 3. In house maintenance of autoclave or service contract.	1. Each cycle 2. One sterilizing cycle per month. 3. Once per year	Log book

CALIBRATION AND MAINTENANCE			
INSTRUMENT	ACTIVITY	FREQUENCY	DOCUMENTATION
Microbiological incubators, and water baths	1. Thermometers in each unit are immersed in liquid to the appropriate immersion line ❑ 2. The thermometers shall be graduated in increments of 0.1 C	Temperature of incubators and water baths shall be recorded twice a day for each day in use with readings separated by at least four hours	Work sheet
DO electrometer	calibrate as specified in **SOP**	Before use	Work sheet/ log book
DO probe	Maintenance as specify by manufacturer	As needed	Work sheet / log book

10.0 ANALYTICAL METHODS

Drinking water samples analyzed under the safe drinking water act will be analyzed in accordance with USEPA approved methods.

Wastewater samples analyzed under the clean water act will be analyzed in accordance with USEPA approved methods.

10.1 LIST OF ANALYTICAL TESTS, PARAMETER, METHOD REFERENCES, REPORTING LIMIT

See attachment # 6

10.2 WRITTEN PROCEDURES FOR CONDUCTING ANALYTICAL TEST

A written procedure for conducting each of the analytical tests performed at the laboratory is available.

See attachment #7 for the SOP Listing

10.3 WRITTEN PROCEDURE FOR CONDUCTING METHOD VALIDATION AND/OR INITIAL DEMONSTRATION OF PERFORMANCE

a) Prior to the implementation of a method, the laboratory will prepare an initial demonstration of method performance in accordance with method specification. When the USEPA approved method does not specify initial demonstration of performance, the laboratory will use the following guidelines:
   1) Determination of Method Detection limits
   2) Precision
   3) Bias

b) Initial demonstration of method performance will be repeated each time significant changes are made to instrumentation, personnel, or the method. Initial demonstration of performance will be documented. The documentation will include the following initial demonstration of capability form.

   See attachment #8

c) The process for conducting method validation and/or initial demonstration of performance, are included in the laboratory written procedure for each analysis.

10.4 EXCEPTIONALLY PERMITTING DEPATURES FROM DOCUMENTED PROCEDURES OR STANDARD SPECIFICATIONS

a) The Laboratory's goal is to produce the highest quality data possible following NELAC guidance, state and method requirements. On occasion there are problems with sample integrity, method QC, etc. Each situation is unique and will be handled on a case by case basis. The QA Manager and or the Laboratory Manager will be notified of the situation and the course of action will be developed. All information will be documented on the appropriate paperwork, i.e. chain of custody, log books, Quality control check request form etc. Many SOP's have method specific situations were deviations may occur, for example if a CCV is out of control on the high side and data that has been analyzed is clean, the results can be reported.

Every effort should and will be made to re-sample, re-analyze etc., to produce acceptable data. But in the event none of these are possible the client will be made aware of the problem. All data reported with quality, integrity etc. issues will be flagged as such. This can include notations on the COC of incorrect sample containers or preservation etc.

Any situation that does occur is also an opportunity to review the way samples are handled from receipt through reporting to see if better processes can be implemented.

11.0 INTERNAL QUALITY CONTROL PROCEDURES

11.1 INTERNAL QUALITY CONTROL PROCEDURES AND FREQUENCY OF USE

The laboratory will demonstrate the quality of analytical results through the implementation of an internal quality control plan.

a) Chemical Testing

1) Method blanks- Method blanks will be performed each day to demonstrate the analytical system, and/or reagents are not contaminated. When the result of a method blank exceed a concentration greater than 1/10 of the measured concentration of any sample in the associated batch and 1/10 of the regulatory limit, the laboratory will minimize or eliminate the contamination problem (when possible) and determine the effect of a contaminated method blank on the samples tested. Any samples affected by a contaminated method blank will be re-analyzed (when possible) or sample results will be qualified.

2) Matrix spikes – will be used to determine analytical accuracy and potential matrix interference. Percent recovery will be calculated by the laboratory and acceptance criteria will be established per matrix. Acceptance criteria will updated annually. Sample results will be qualified when matrix spike recovery is outside the acceptance limits.

Matrix spike and matrix spike duplicates will be selected at random from the batch of client samples to be prepared or analyzed that day. This procedure will be followed unless the client species on the COC one of their samples are to be analyzed as the MS/MSD.

a) The following calculation will be used to determine Percent Recovery:

$$\%R = [(SSR-SR)/SA] * 100$$

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added

The laboratory will spike all target analytes during the course of a year.

b) The Acceptance Limits will be calculated annually using the following calculation:

Upper Control Limits = p + 3s
Lower Control Limits = p – 3s

Where p = the average percent recovery of at least 15 results
s = the standard deviation of the percent recoveries.

3) Laboratory control samples – Laboratory control samples will be used to determine the accuracy of the analysis. The laboratory will calculate percent recovery and establish acceptance criteria. The following calculation will be used to determine percent recovery.

%R = (Conc. found ÷True Conc.) * 100

Acceptance limits will be calculated using the same calculation as for the matrix spike limits.

4) Matrix spike duplicate or laboratory duplicates – Matrix spike duplicates or laboratory duplicates will be used to determine analytical precision. Relative percent difference or percent difference will be calculated by the laboratory. Acceptance criteria will be established annually. Sample results will be qualified when %RPD are outside the laboratory's acceptance limits. The following calculation will be used to determine %RPD:

%D = [|S-D| ÷ (S+D) ÷] *100

S = Original Sample Result
D = Duplicate sample result

%RPD = [|MS – MSD| ÷ (MS + MSD) ÷ 2] * 100.

MS = % Rec. of Matrix Spike Sample
MSD = % Rec. of Matrix Spike Duplicate Sample

5) Surrogates – For the analysis of organic compounds, surrogate compounds shall be spiked into each sample, standard, QC sample, and blank. Percent recoveries will be calculated and acceptance criteria will be established.

6) Method blanks, matrix spikes, matrix spike duplicates, laboratory control samples and laboratory duplicates will be performed at a frequency of one per batch or as stated in the method.

7) Method detection limits (MDL) will be calculated annually according to 40CFR Part 136, Appendix B (Oct. 26, 1984) or according to method specifications. The laboratory will document the matrix used for the MDL

studies. MDL's are not required for analysis used to determine physical properties such as residues, Dissolved oxygen and pH.

MDL's are calculated annually or semiannually (method specific) by analyzing 7 replicates that are 2-5 times the lowest calibration or reporting limit.
The MDL is calculated by multiplying the Standard Deviation for the multiple measurements by the student's T value (3.14 for seven measurements).
The laboratory reporting limit must be higher than the calculated MDL. Ideally it should be 3-5 times higher than the calculated MDL. At no time can the reporting limit be less than the MDL.

8) Selectivity – For the analysis of organic compounds, the laboratory will develop and document acceptance criteria for retention time windows as determined by the approved method. When mass spectrometers are used for the analysis of samples, the laboratory will develop and document acceptance criteria for mass tuning. Confirmation is required for all positive results on samples from locations where previous data is not available. Confirmation is not required when mass spectrometers are used for the analysis.

b) Microbiological Testing

1) Uninoculated controls, laboratory water, and sterilized equipment and supplies will be tested as provided for in the approved method.

2) Confirmation/verification tests – The laboratory will perform confirmation and verification test as specified by the approved methods.

3) Inhibitory residues – The laboratory will check each lot of laboratory detergent to ensure residues from the detergent do not inhibit or promote growth of micro-organisms.

4) Media – All test media will be checked with positive and negative control organisms to ensure the target organisms respond in an acceptable and predictable manner. These controls will be run with each new lot of media or at least monthly. Laboratories will use reference cultures of micro-organisms obtained from Difco or equivalent source.

5) Precision – at least five percent of suspected positive samples will be duplicated to determine precision. Comparison analysis between multiple analysts will be conducted on at least one sample per month.

11.2 PROCEDURES TO DETERMINE ACCEPTANCE CRITERIA

a) Precision is used as a data quality indicator to determine the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.

b) Chemserve will determine precision through the use of duplicates and/or matrix spike duplicates. Percent difference (%D) between duplicates and Relative Percent Differences (RPD) between matrix spike duplicates will be calculated.

c) Acceptance criteria for duplicate analysis will be established at a warning limit of two standard deviations, and a control limit of three standard deviations of the %D or RPD. Acceptance criteria will be monitored daily by observing the results of the daily QC samples.

d) Accuracy is used as a data quality indicator to determine the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations.

e) Chemserve will determine accuracy through the use of standards of known concentrations. Percent recoveries (%Rec) will be calculated. Acceptance criteria for LCS, MS and surrogates will be established using warning limits set at two standard deviations and control limits set at three standard deviations of the %Rec. Acceptance criteria will be monitored daily by observing the results of the daily QC samples.

f) Acceptance Limits will be established using the following calculations

Calculate the average % Recovery of at least 15-20 data points.

$$\text{Mean} = \frac{x}{n}$$

Calculate the Standard Deviation:

$$\sqrt{\frac{\sum_{i=1}^{n}(x - mean)^2}{n-1}}$$

x = each data point
mean = average of all data points

n = number of data points

Calculate the Upper control Limit (UCL) and the Lower Control Limit as ±3 SD

UCL = Mean + 3SD
LCL = Mean – 3SD

Calculate the Upper Warning Limits (UWL) and the Lower Warning Limits (LWL) as ±2 SD.

UWL = mean + 2SD
LWL = mean – 2SD

11.3 ACCEPTANCE CRITERIA REVIEWS

Acceptance criteria will be reviewed (and updated if necessary) annually. Batch QC data will be reviewed daily to verify that it meets the acceptance limits set by the laboratory. Analytical data will be reanalyzed or flagged as necessary based on this review.

12.0 DATA REDUCTION AND REPORTING

12.1 PROCEDURES FOR DATA REDUCTION

a) 5-day BOD

The results of dilutions of samples having a residual DO of at least 1mg/L and a DO depletion of at least 2mg/L are used to calculate the BOD results. Calculations are as outlined in Standard Methods for the Examination of Water and Wastewater, 18th Ed., p5-5.

$$BOD_5 = \frac{(d_1 - D_2) - (B_1 - B_2)\,f}{P}$$

D_1 = DO of diluted sample immediately after preparation, mg/L
D_2 = DO of diluted sample after 5d incubation, mg/L
P = volume of sample used
B_1 = DO of seed control before incubation, mg/L
B_2 = DO of seed control after incubation, mg/L
F = ratio of seed in diluted sample to seed in seed control
=(% seed in diluted sample)/(% seed in seed control)

b) Alkalinity
Calculations are as outlines in Standard Method for the Examination of Water & Wastewater, 18th ed. p.2-27.

$$\text{Alkalinity as mg } CaCO_3/L = \frac{A \times N \times 50{,}000}{\text{Ml sample}}$$

Where:
A = ml of Acid titrant used
N = Normality of H_2SO_4

c) Ammonia
Calculations are as outlined in Standard Methods for the Examination of Water & Wastewater, 18th Ed.,p 4-83.

$$\text{mg NH3-N/L} = A \times B \times \frac{[101 + C]}{101}$$

where:
A = dilution factor
B = concentration of NH_3 –N/L, mg/L from calibration curve.

C = volume of added 10N NaOH in excess on 1ml.

d) Chloride

Calculations are as outlined in Standard Methods for the Examination of Water and Wastewater, 18th Ed. P 4-49.

$$\text{mg } Cl^-/L = \frac{(A-B) \times N \times 35450}{\text{ml sample}}$$

Where:

A = ml of titrate for sample
B = ml of titrate for blank
N = Normality of $AgNO_3$

e) Cyanide

Calculation are as outlined in Standard Methods for the Examination of Water and Wastewater, 18th, ed. p.4-25

$$Cn^- \text{ mg/L} = (ma_1 + b) \times \frac{50}{X} \times \frac{250}{Y}$$

Where:

m = slope of standard curve
a_1 = absorbance of sample solution
b = intercept on c axis
X = Absorption solution, mL
Y = original sample volume, mL

f) Hardness

Calculation are as outlined in Standard Methods for the Examination of Water and Wastewater, 18th, ed. p.2-36.

$$\text{mg equivalents } CaCO_3/L = 2.497(\text{Ca mg/L}) = 4.118(\text{Mg mg/L}).$$

g) Nitrogen – Total Kjedahl

Calculations are as outlined in Standard Methods for the Examination of Water & Wastewater, 18th Ed.,p 4-83.

$$\text{mg NH3-N/L} = A \times B \times \frac{[101 + C]}{101}$$

where:

A = dilution factor

B = concentration of NH_3 –N/L, mg/L from calibration curve.

C = volume of added 10N NaOH in excess on 1ml.

h) Oil and Grease grav.
Calculations are as outlined in EPA 1664

$$\text{mg O\&G/L} = \frac{(A - B) \times 1000}{\text{ml of sample}}$$

Where

A = Total gain in weight of tared flask, g
B = weight of residue in blank, g

i) Phenol
Calculations are as outlined in Standard Methods for the Examination of Water & Wastewater, 18th Ed.,p 5-33

$$\text{mg phenol/L} = \frac{A}{B} \times 1000$$

Where:

A = mg phenol in sample from cal curve
B = volume of original sample mL.

j) Sulfite
Calculations are as outlined in EPA method 377.1, 1978.

$$\text{mg/L } SO_3 = \frac{A \times N \times 40{,}000}{\text{ml sample}}$$

where:

A = ml titrant-B, ml
B = ml titrant for blank
N = normality of $KI\text{-}KIO_3$ titrant

k) Sulfide – Reactivity
Calculations are as outlined in SW846 7.3.4.2.

$$\text{Total Releasable } H_2S \text{ (mg/Kg)} = R \times 1{,}800$$

Where:

$$R = \text{Specific rate of release} = \frac{A - L}{W - S}$$

A = Conc. of H_2S in scrubber by colormetric
L = Vol. of solution in scrubber, L
W = wt. of waste used, Kg
S = Time of measurement = Time N_2 stopped – Time N_2 started, seconds

l) Surfactants as MBAS
Calculations are as outlined in Standard Methods for the Examination of Water & Wastewater, 18th Ed.,p 5-38

$$\text{mg MBAS/L} = \frac{\text{ug apparent LAS}}{\text{ml original sample}}$$

ug apparent LAS is read from the calibration curve.

m) Turbidity
Calculations are as outlined in EPA method 180.1, 1978.

$$\text{Results in NTU} = \frac{A \times (B + C)}{C}$$

Where:
A = instrument reading in NTU
B = Volume of dilution water.
C = Volume of sample used

n) Total Solids – Residue
Calculations are as outlined in EPA method 160.3, 1978.

$$\text{mg total solids/L} = \frac{(A-B) \times 1000}{\text{sample volume ml}}$$

Where:
A = Weight of dried residue + dish, mg
B = weight of dish, mg

o) Total Dissolved Solids
Calculations are as outlined in EPA method 160.1, 1971.

$$\text{TDS in mg/L} = \frac{(A-B) \times 1000}{C}$$

Where:

A = Weight of dried residue and dish, mg
B = weight of dish, mg
C = ml of sample filtered.

p) Total Suspended Solids
Calculations are as outlined in EPA method 160.2, 1971.

$$\text{TSS in mg/L} = \frac{(A-B) \times 1000}{C}$$

Where:

A = Weight of filter and sample residue, mg
B = weight of filter, mg
C = ml of sample filtered.

12.2 REPORTING PROCEDURES AND FORMAT

a) All data is reported with all the following sample information:

1) Report Title, name of the laboratory, and accreditation number
2) Location of sample test
3) Contact person and phone number at the laboratory
4) Unique identification number of the report
5) The laboratory shall provide the total number of pages on the report
6) Identification of the client or project name, or both (when applicable)
7) Identification of the sample with field sample number (when available)
8) Description of the sample matrix (water, solid, product)
9) Date the sample was received
10) Date and Time of collection is noted on the COC. The date of collection is noted on reports.

11) Date(s) of analysis

12) Identification of the method used, or method number

13) Reference to sampling procedure when relevant

14) Data qualifiers to describe analytical conditions

15) Analytical data is reported in units consistent with monitoring program requirement

16) Signature and title of the person accepting responsibility for the content of the report

17) Date issued

18) Any reports issued by the laboratory with amendments to a previous report, shall be clearly identified as an amended report.

19) When reporting to the State of DES reporting form, the above requirements are not all applicable. The state form must be filled out as required. The laboratory may report and sign forms for only data generated by the laboratory.

b) If the laboratory subcontracts part or all of the sample to another laboratory:

1) The test report must indicate any subcontracted data if the data is submitted on the laboratory's reporting form.

2) Only the laboratory actually doing the analysis will sign state form, copies of the state form will be provided to each subcontract laboratory, as needed.

12.3 PROCEDURES TO ENSURE REPORTED DATA IS FREE FROM ERRORS. DATA VALIDATION

a) All data is first reviewed by the analyst performing the analysis. The data review will include the following items.

1) Calibration of the instrumentation

2) Quality control data. Confirm QC data meets the acceptance limits.

3) Calculation, check for calculation errors.

4) Documentation, Check worksheets/logbooks and printouts for completeness including sample number, dilution factors and comments.

5) The data is then entered into the LIMS system by the analyst. The LIMS system is updated from entered to edit, to reflect the changed status of the sample.

b) The dept. manager or qualified analyst does a second review of the data. This includes the following items

1) The LIMS results are verified to the raw data.

2) All header information is verified, this includes sampling date, date of analysis, sample ID, dilution factors, etc.

3) Surrogates results and Batch QC are verified for control.

4) Data is updated to approved in LIMS

5) Results are forwarded to QA for final compilation and approval.

c) Final QA Review

1) QA reviews all data turned in from the various departments for completeness and accuracy.

2) All data is compiled and compared to the original COC for completeness

3) The entire report is approved in LIMS and the final report is printed.

4) Results are reviewed to raw data for accuracy.

5) All header information is reviewed for accuracy.

6) QA signs the final report

d) The lab director or designee does a final review and signs the final report.

12.4 PROCEDURES FOR DATA QUALIFIERS

Data qualifiers will be added to all data not meeting collection, anlaytical or internal QC acceptance criteria. Data qualifiers can be added to the system at the time of login, by the analyst, data reviewer or by QC. A non-conformance summary will be filled out by the analyst or data reviewer. This form will be forwarded to QA so the appropriate client calls can be made.

13.0 PROFICIENCY TESTING

13.1 THE TYPE AND FREQUENCY OF PROFICIENCY TESTING

a) Chemserve will obtain Performance Evaluation samples Environmental Resource Associates, Chrisope Technologies (microbiology) or other NELAC approved providers as necessary.

b) Performance Evaluation samples for Drinking water for microbiology and chemistry will be analyzed in February and August of each year.

c) Performance Evaluation samples for Wastewater will be analyzed in May and November of each year.

d) PT studies will be analyzed in the same manner and at the same frequency as regular samples.

e) The same calibration procedures and the same internal QC protocol will be used when analyzing PT studies.

13.2 PROCEDURES FOR THE DETERMINATION OF THE CAUSE OF A FAILED STUDY AND PROCEDURES FOR CORRECTION ACTION

a) If the laboratory fails a PT study, an investigation of the cause will be conducted. Corrective action will be documented on the Quality Control Check Request form.

b) Documentation of the PT analysis will be reviewed and the way the analysis was conducted will be investigated. When problems are identified, a corrective action plan will be outlined and put in place in a timely manner.

c) A corrective action letter will be prepared and sent to NH ELAP within 30 days of receiving the unacceptable result.

d) The failed PT analyte will be repeated after corrective action has been completed. Results will be sent to NH-ELAP directly from the PT provider.

14.0 CORRECTIVE ACTION

a) The laboratory will take corrective action whenever unacceptable conditions exist. The following indicators will be used to determine unacceptable conditions:

1) QC samples outside the established acceptance criteria.

2) Calibration outside acceptable criteria.
No analysis will occur if the calibration does not fall within acceptable limits. In most cases, instrument maintenance may be required. New calibration standards will be prepared or purchased as necessary. A valid calibration curve will be completed and verified before analysis can occur.

3) Equipment failure
Instrument maintenance will be completed as required. Outside service call will be completed as needed. Instruments must be re-calibrated after equipment failure and/or repairs.

4) PT studies outside acceptable limits
See section 13.2

5) Deficiencies identified during internal reviews
Deficiencies found during internal reviews will be addressed as needed. This could include SOP revisions, analyst retraining, Logbook revisions, etc. All corrective actions will be put in writing and be included with the internal review report.

6) Deficiencies identified during NH ELAP's on-site assessments.

7) Deficiencies or problems identified after receiving a complaint.
All client complaints will be documented on the Quality Control Check Request form. This form is forwarded to the QAO. The QAO will investigate the complaint, reviewing data, logbooks, calibrations, etc. Re-analysis or re-sampling may be required. The client will be informed of the results either verbally or in writing. Reports will be reissued as necessary. If laboratory procedures require changes this will be put in writing and require sign off by the laboratory manager and analysts.
The Quality Control Check Request form and all associated documentation will be kept on file.

b) All corrective action taken by the laboratory will be documented.

c) If the laboratory determines the validity of the data are compromised, the laboratory will take corrective action and make written notification to any affected clients.

SPECIFIC CORRECTIVE ACTION		
TYPE	**RECOMMENDED ACTION**	**DOCUMENTATION**
Contaminated Method Blank	1. Determine source of contamination. 2. Eliminate source of contamination 3. Re-analyze blank	Logbook
LCS outside acceptance limits	1. Check preparation log for errors 2. Check analysis for errors. 3. Check calculations 4. Remake standard or use a different standard. 5. Re-analyze standard and all affected samples.	Logbook
Analyst not following SOP	1. Provide additional training with train and sign form 2. Do demonstration of analysis 3. Analyze a PT sample.	Training File, Logbook
Positive/Negative controls	4. Check expiration date of the media 5. Check media preparation 6. Confirm incubator temps. 7. Prepare new media from same lot, if still not acceptable, prepare media from different lot. 8. Examine Analytical technique.	Logbook

15.0 INTERNAL AUDITS

15.1.a INTERNAL AUDITS OF THE QUALITY SYSTEM

The laboratory will conduct various internal audits to verify that its operation continues to comply with the requirements of the Quality System. This will include annual review of the Quality System Manual to ensure its continued compliance with NELAC requirements, performance audits, method audits and SOP updates. The annual certification renewal will be the starting point for the annual reviews. Such audits will be conducted by the QAO or designee. Where the audit identifies problems with correctness or validity of the laboratory's calibration or test results, the laboratory will implement a corrective action plan to solve the problems.

15.1.b The Quality System Manual will be reviewed by the QAO for any discrepancies from the "Documentation Checklist" provided with the annual certification renewal. All changes made to the Quality System Manual will be reviewed by the Laboratory Operations Manager and the Laboratory director. Documentation of any changes will be kept on file. All attachments such as equipment lists, SOP lists, etc., that are subject to change during the year will be updated as needed in the computer. The printed version will be replaced annually.

15.2 PERFORMANCE AUDITS

On an on going basis, Chemserve will ensure the quality of the data by implementing the following checks:

a) Participation in proficiency testing or other interlaboratory comparisons
b) Use of certified reference materials and/or in-house quality control using secondary reference materials.
c) Replicate testing using the same or different test methods.
d) Re-testing of retained samples
e) Correlation of results for different parameters of a sample (for example chrome-6 should be less than or equal to total chrome)

15.3 DOCUMENTATION OF AUDITS OR REVIEWS

All audit and review findings and any corrective actions that arise from them will be documented.

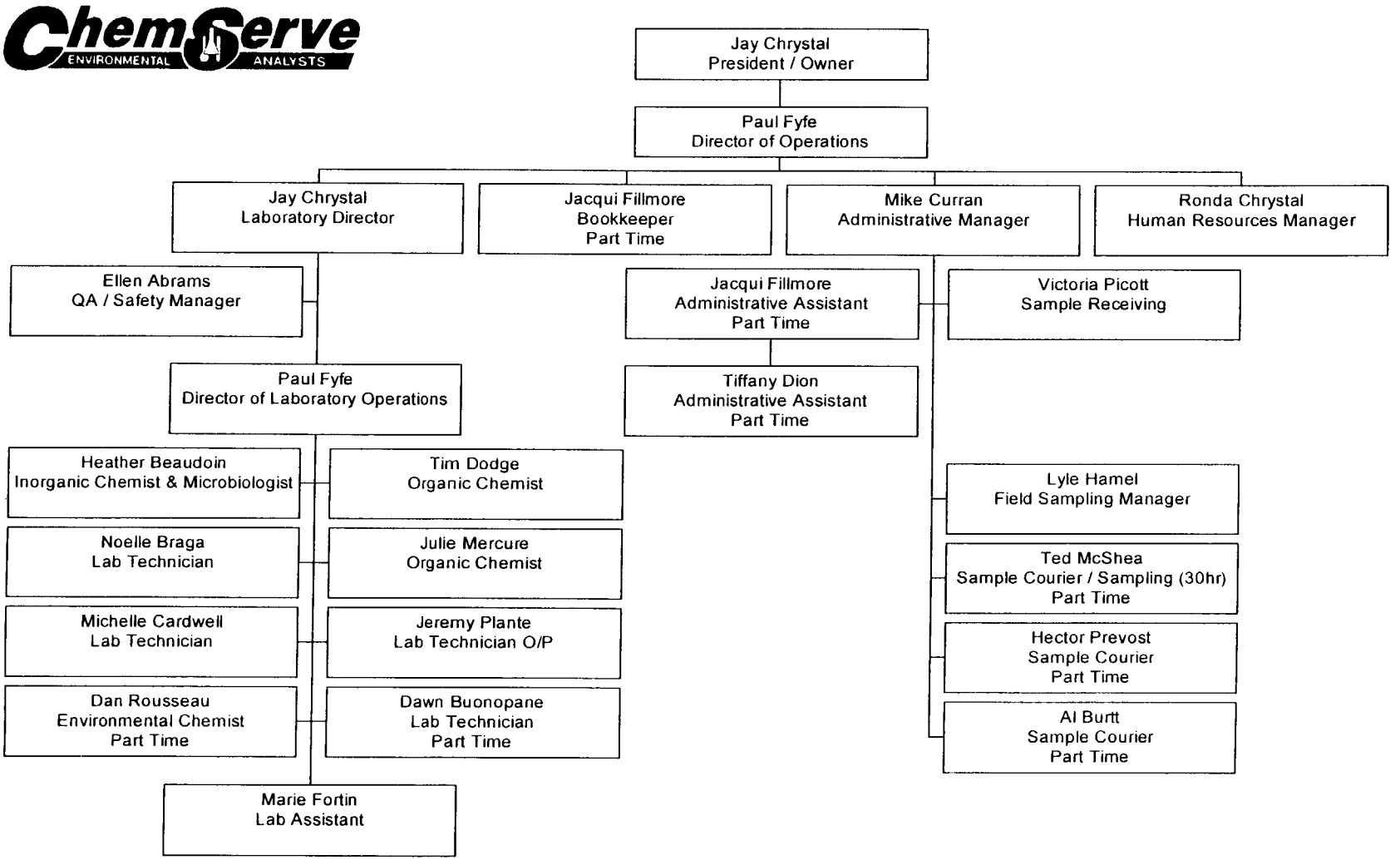
The laboratory management will ensure that these corrective actions are implemented within the agreed time frame.

Where the audit or review identifies problems with correctness or validity of the data, the laboratory will immediately notify, in writing, the client whose work may have been affected.

ATTACHMENTS

ATTACHMENT #1

Chemserve Organization Chart February 2005



ATTACHMENT #2

ChemServe ENVIRONMENTAL ANALYSTS

Attachment #2

PERSONNEL QUALIFICATIONS

NAME	POSITION	DEGREE	YEARS EXPERIENCE
Jay Chrystal	Lab Director/ President	BS/Bio/Chem	20
Ellen Abrams	QA Manager	BS/Bio/Env.Science	18
Paul Fyfe	Dir. Lab Operations/Inorganic Chemist	AA/Chem	17
Heather Beaudoin	Inorganic Chemist/ Microbiology	BS Biology	4
Timothy Dodge	Organic Chemist	BS Biology/Minor Chemistry	4
Julie Mercure	Organic Chemist	AA Science	23

ATTACHMENT #3

EQUIPMENT	*MAKE AND MODEL*	*APPROX AGE (years)*	*Date Recv'd*	*Date in Service*	*Laboratory Location*
AUTOCLAVE	MARKET FORGE 010084	14	N/A	N/A	Prep Lab
BALANCE	Acculab LA-110 (ANALYTICAL)	3	N/A	N/A	Wet Chem Lab
BALANCE	METLER P2000 TOP LOADING	9	N/A	N/A	
BALANCE	SARTORIUS TOP LOADER	9	N/A	N/A	Prep Lab
BLENDER	WARING	9	N/A	N/A	
BOD METER	54 PORTABLE BOD METER-YSI	-	N/A	N/A	Org. Lab
BOD METER	51A PORTABLE BOD METER-YSI	9	N/A	N/A	Org. Lab
BOD METER	YSI MODEL 50 B	9	N/A	N/A	Org. Lab
BOD STIRRING PROBES	BOD STIRRING PROBES	-	N/A	N/A	Org. Lab
CENTRIFUGE	DYNEC	7	N/A	N/A	Prep Lab
COD REACTER	HACH 97090016509	7	N/A	N/A	Prep Lab
CHLORINE TEST KIT TOTAL & RESIDUAL	HACH POCKET COLORIMETER 46700-12	-	N/A	N/A	
COMPRESSOR	DAYTON OILESS	11	N/A	N/A	Warehouse
COMPRESSOR	A. SHIELD COMPRESOR OILLESS	11	N/A	N/A	Warehouse
CYANIDE MINIDISTILLATION	LABLINE 1096-00	7	N/A	N/A	ICP Room
CONDUCTIVITY METER	FISHER SCIENTIFIC 97056846	6	N/A	N/A	Wet Chem Lab
DEPTH INDICATOR	SLOPE INDICATOR CO. DEPTH INDICATOR	-	N/A	N/A	
DESICATOR	DESICATORS-VWR		N/A	N/A	Prep Lab
DRYING OVEN	Precision	3	N/A	N/A	Warehouse
EYE WASH/SHOWER	VWR EYE WASH SHOWER UNIT	15	N/A	N/A	Prep Lab
FILTERS-MEMBRANE	MILLIPORE FILTER APPARATUS	4	N/A	N/A	Bact. Room
FLASHPOINT	PRECISION SCIENTIFIC FLASHPOINT ANALYZER	12	N/A	N/A	Prep Lab
FREEZER	AMANA	8	N/A	N/A	Prep Lab
FREEZER	GE CHEST TYPE	9	N/A	N/A	Warehouse
FREEZER	GE STAND-UP	8	N/A	N/A	Wet Chem Lab
FUME HOOD	8 FOOT KEWANEE	10	N/A	N/A	Prep Lab
FUME HOOD	2 FOOT STAINLESS	7	N/A	N/A	Org. Lab
FURNACE	Fisher Isotemp Muffle furnace	3	N/A	N/A	Prep Lab
G.C.- EVAPORATOR	ZYMARK TURBO VAP -SOLVENT CONCENTRATORS	9	N/A	N/A	Prep Lab
G.C. EVAPORATORS	ZYMARK TURBO VAP SOLVENT CONCENTRATORS	4	N/A	N/A	Prep Lab
G.C. FID	H.P. 5890 SERIES II PLUS EPC GC FID DUAL DETECTOR	9	N/A	N/A	Org. Lab
G.C. FID	H.P. 7673 AUTOSAMPLER	9	N/A	N/A	Org. Lab

EQUIPMENT	*MAKE AND MODEL*	*APPROX AGE (years)*	*Date Recv'd*	*Date in Service*	*Laboratory Location*
G.C.-ULTRASONIC EXTRACTOR	TEKMAR-ULTRASONIC EXTRACTION PROBE	9	N/A	N/A	Prep Lab
G.C.-ULTRASONIC EXTRACTOR	SONICATOR-ULTRASONIC EXTRACTION PROBE	9	N/A	N/A	Prep Lab
GC PID/FID**	SRI GC MODEL 8610A w/PeakNet Windows Datastation	11	N/A	N/A	Voa Room
GC/MS-5970	5890 GAS CHROMATOGRAPH H.P. w/Chemstation DOS and Enviroquant DataStation	14	N/A	N/A	Org. Lab
GC/MS-5970	5970 H.P. MASS SELECTIVE DETECTOR	14	N/A	N/A	Org. Lab
GC/MS-5971	H.P. MODEL 5890 SERIES II EPC GC w/Chemstation DOS and Enviroquant DataStation	11	N/A	N/A	Org. Lab
GC/MS-5971	H.P. MODEL 5971 SERIES MS	10	N/A	N/A	Org. Lab
GC/MS-5971	H.P. MODEL 7673 100SK AUTO SAMPLER	10	N/A	N/A	Org. Lab
GC/MS-5972	5890 SERIES II PLUS EPC GC w/Chemstation DOS and Enviroquant DataStation	8	N/A	N/A	Org. Lab
GC/MS-5972	TEKMAR 2016 AUTOSAMPLER	8	N/A	N/A	Voa Room
GC/MS-5972	TEKMAR 3000 CONCENTRATOR	8	N/A	N/A	Voa Room
GC/MS-5972	5972 MASS SELECTIVE DETECTOR	8	N/A	N/A	Voa Room
GC-AUTOSAMPLER	7673B HP DIRECT INJECTION AUTOSAMPLER	4	N/A	N/A	Org. Lab
GC-ECD	H.P. MODEL 7673 100SK AUTOSAMPLER	11	N/A	N/A	Org. Lab
GC-ECD	5890 SERIES II GC ECD-DUAL DETECTOR w/ Chemstation DOS and Enviroquant Data Station	11 ECD refurbished 2005	N/A	N/A	Org. Lab
GENERATOR	5000W YAMAHA	8	N/A	N/A	Warehouse
GLASSWARE	LARGE INVENTORY OF ALL TYPES OF GLASSWARE, PIPETS, DISTILATION SETUPS ETC.	N/A	N/A	N/A	All Labs
HEAT BLOCK	Technicon BD-40	4	N/A	N/A	Prep Lab
HEATING MANTLE	ELECTROTHERMAL	7	N/A	N/A	
HOT PLATE	Cimarec-3 thermolyne hot plate	3	N/A	N/A	Prep Lab
HOT PLATES	CORNING	Various-	N/A	N/A	Prep & Wet Chem Labs
HOTPLATE	BRONWILL HOT PLATE	Various	N/A	N/A	"
HOTPLATE/STIRPLATE	PC-101 CORNING HOT PLATE	Various	N/A	N/A	"

EQUIPMENT	*MAKE AND MODEL*	*APPROX AGE (years)*	*Date Recv'd*	*Date in Service*	*Laboratory Location*
HPLC	WATERS MULTIWAVELENGTH UV/VIS DETECTOR	5	N/A	N/A	Org. Lab
HPLC	PCX-5000 PICKERING POST-COLUMN DERIVITIAZTION UNIT	5	N/A	N/A	Org. Lab
HPLC	HP 1016 FLUORESCENCE DETECTOR	5	N/A	N/A	Org. Lab
HPLC	DETECTOR UV/VIS MILLIPORE WATERS M-490	11	N/A	N/A	Org. Lab
HPLC	HP 1050 W/QUAD PUMPS	11	N/A	N/A	Org. Lab
IMOFF CONES	IMOFF CONES	-	N/A	N/A	Wet Chem Lab
IMOFF RACK	IMOFF RACK	-	N/A	N/A	Wet Chem Lab
INCUBATOR	INCUBATOR OVEN-PRECISION SCIENTIFIC-COLIFORM	11	N/A	N/A	Bact. Room
INCUBATOR	VWR model 2020	3	N/A	N/A	Bact. Room
ION CHROMATOGRAPH	DIONEX DX120 w/PeakNet Windows Data Station	6	N/A	N/A	Wet Chem Lab
MAGNETIC STIRRER	ROUND MAGNETIC STIRRER-FISHER	Various	N/A	N/A	Prep & Wet Chem Labs
MAGNETIC STIRRER	CORNING	Various	N/A	N/A	"
MAGNETIC STIRRER	THERMOLINE (ROUND)	Various	N/A	N/A	"
MAGNETIC STRRER	THERMOLYNE MAGNETIC STIRRER-LIGHTED	Various	N/A	N/A	"
MOBILE LABORATORY	12' PACE TRAILER W/CABINETS, REFRIGERATOR, FLAMMABLE STORAGE	Sold 2003	N/A	N/A	N/A
MTL AA AUTO SAMPLER	Perkin Elmer AS-60 GRAPHITE AUTO SAMPLER	8	N/A	N/A	ICP Room
MTL AA GRAPHITE FURNACE	Perkin Elmer HGA 600 GRAPHITE FURNACE	8	N/A	N/A	ICP Room
MTL AA SPECTROPHOTOMETER	PERKIN ELMER 3110	8	N/A	N/A	ICP Room
MTL MERCURY ANALYZER	SPECTRO MERC W/AUTO SAMPLER	7	N/A	N/A	ICP Room
MTL PRINTER	PRS-10 PRINTER SEQUENCER	14	N/A	N/A	ICP Room
MTL-AA- LAMPS	PERKIN ELMER A.A. LAMPS	-	N/A	N/A	ICP Room
MTL-ICP	SPECTRO-SEQ/SIM MODEL ICP	Sold 2003	N/A	N/A	N/A

EQUIPMENT	*MAKE AND MODEL*	*APPROX AGE (years)*	*Date Recv'd*	*Date in Service*	*Laboratory Location*
(38 CHANNELS) w/ Autosampler			N/A	N/A	N/A
MTL-MCROWAVE	CEM MDS 2100 MICROWAVE DIGESTION OVEN	7	N/A	N/A	Prep Lab
OVEN	FISHER Isotemp model 300	9	N/A	N/A	Prep Lab
PARR BOMB	OXYGEN BOMB COLORIMETER	>6	N/A	N/A	ICP Room
pH METER	EXTECH OYSTER MULTIMETER	8	N/A	N/A	Field Services
pH METER	ORION E.A. 940		N/A	N/A	N/A
pH METER	ACCUMET 915	10	N/A	N/A	
PIPET WASHER	PIPET WASHER VWR	-	N/A	N/A	Wet Chem Lab
PROBES-ION SELECTIVE	ASSORTED ION SELECTIVE, REF & pH	-	N/A	N/A	Wet Chem Lab
REFRIGERATORS	EXPLOSION PROOF	8	N/A	N/A	Org. Lab
REFRIGERATORS	REVCO 3 BAY	8	N/A	N/A	Warehouse
SAMPLER-FIELD	ISCO SEQUENTIAL/COMPOSITE SAMPLER (2)2700 & (2)3700	Various	N/A	N/A	Warehouse
Micro Scope	BAUSCH & LOMB MICROSCOPE	16	N/A	N/A	Bact. Room
Micro Scope	A.O. DISECTION SCOPE	16	N/A	N/A	Bact. Room
SPECTROPHOTOMETER	MILTON ROY SPECTRONIC	11	N/A	N/A	ICP Room
SPECTROPHOTOMETER	PERKIN ELMER LAMBDA 3BUV/VIS	11	N/A	N/A	ICP Room
TCLP FILTER	MILLIPORE FILTER APPERATUS	12	N/A	N/A	Prep Lab
TCLP FILTER	ASSOCIATED DESIGN FILTER APPARATUS	12	N/A	N/A	Prep Lab
TCLP ROTORY AGITATOR	ADVANCED DESIGN	11	N/A	N/A	ICP Room
TCLP ROTORY AGITATOR	ADVANCED DESIGN	8	N/A	N/A	ICP Room
TCLP ROTORY AGITATOR	ANALYTICAL TESTING	9	N/A	N/A	ICP Room
TCLP ROTORY AGITATOR	ANALYTICAL TESTING	9	N/A	N/A	ICP Room
TCLP ROTORY AGITATOR	ANALYTICAL TESTING 8 Liter Size	9	N/A	N/A	ICP Room
TCLP ZHE EXTRACTORS	MILLIPORE	10	N/A	N/A	ICP Room
TCLP ZHE TUMBLER	MILIPORE	8	N/A	N/A	ICP Room
TEFLON BAILERS	NORCO	-	N/A	N/A	Field Services
TURBIDIMETER	HACH RATIO XR	8	N/A	N/A	Wet Chem Lab
ULTRASONIC BATH	BRANSON	9	N/A	N/A	Org.Lab
VACUUM PUMP	GAST 9.0 AMP	7	N/A	N/A	Org. Lab
VACUUM PUMP	EDWARDS	-	N/A	N/A	Org. Lab
VACUUM PUMP	GAST 4.2 AMP	-	N/A	N/A	Bact. Room
WALK-IN COOLER	BUILT-IN	15	N/A	N/A	Wet Chem Lab
WATER BATH	MAGNI-WHIRL BLUE M BATH	-	N/A	N/A	Bact. Room
WRIST SHAKER	BURELL MODEL DD	14	N/A	N/A	Prep Lab
GC/MS 5972	Hewlett Packard	3	N/A	N/A	Voa Room

EQUIPMENT	*MAKE AND MODEL*	*APPROX AGE (years)*	*Date Recv'd*	*Date in Service*	*Laboratory Location*
Autosampler 2016	Tekmar	3	N/A	N/A	Voa Room
Purge and Trap concentrator	Tekmar 3000	3	N/A	N/A	Voa Room
GC 5890	Hewlett Packard series II	3	N/A	N/A	Org. Lab
TCD/FID detector	Hewlett Packard	3	N/A	N/A	Org. Lab
Multi Distillation Unit	LabConco	4	N/A	N/A	Prep Lab
ICP	Spectro Ciros-CCD Model HVNT4 Rev. C	2	04/03	04/03	ICP Room
Cyanide Midi Distillation Unit	Lab Crest Andrew Glass Co. #A370132	2	07/28/03	8/03	ICP Room
Spectronic 501	Milton Roy Spectrophotometer #1083547	~13	07/03	07/03	ICP Room
Dionex ICS 2000	Dionex #04020051	1	02/04	02/04	Wet Chem Lab

Last update 03/05

Deposit Summary

3/7/2005 12:03 PM

Summary of Deposits to 1100 · Cash:1170 · First Colebrook Bank - Checking on 03/07/2005

Chk No.	PmtMethod	Rcd From	Memo	Amount
133151	Check	Merrimack Wastewater Treatment Fa...		1,213.30
64099	Check	Groton School		904.20
154943	Check	Redhook		147.15
112306	Check	Vectron		1,341.90
8769	Check	Aquatic Control Inc		200.00
124736	Check	Fitchburg, City of		324.00
Less Cash Back:				
Deposit Total:				**4,130.55**

ATTACHMENT #4

ChemServe ENVIRONMENTAL ANALYSTS

Attachment #4

Description of Laboratory

	Area Sq. Feet.	Bench Area, Linear ft.
Office Space	2,000	
Record Space	500	
Reception Room	100	
Conference Room	120	
Laboratory Room #1	680	30
Laboratory Room #2	450	33
Laboratory Room #3	525	71
Laboratory Room #4	100	20
Laboratory Room #5	655	120
Laboratory Room #6	120	17
Storage Area	6,200	

Utilities

No. of sinks 7 . Hot Water 7 Cold Water 7
Is the Lab air conditioned? Yes
Type of DI water system Us Filter System
Type of Flooring Cement with tile
Type of overhead lighting Fluorescent

ATTACHMENT #5

Attachment #5

Field Sampling Equipment List

Chemserve owns, operates and maintains equipment, instrumentation, appropriate for all the services we provide.

Inventory

Autosamplers	3 ISCO 2700, with lids
	1 ISCO GLS w/ lid
	2 ISCO 3700, with lids
	4 bases with jug adapters
	8 bases with 24 plastic bottles each with retention rings
	2 sets of 24 glass bottles with wire retention rings
	6 10,000ml plastic jugs
	6 6,500ml glass jug
	1 5 gallon plastic jug
	3 NiCd rechargeable batteries
	4 battery chargers
	1 small deep-cycle marine battery
	2 foam insulated huts
	2 heated huts
Bailers	12 Teflon 2" bailers with sleeves
	1 pvc 1" bailer
	2 Teflon bailer couples
	4 Teflon bailer leads
	2 Slope Indicator
	1 100' electric water level indicator
	1 Tape Measure 200' tape measure
	Soil sampler 1 soil ram rod soil plug sampler
	2 pH Meters Extech Oyster pH, specific conductance and temperature
	2 Chlorine Meter Hach Pocket Colorimeter , free and total chlorine

ATTACHMENT #6

SENDING CONTAINERS

New Customer - check for quote and/or get list of parameters, # of sites and matrix
Existing Customer - check sample, self sampling or quote, customers request, customer information sheet
State Drinking Water - see container chart for proper state
Place a TEMPERATURE BLANK in each cooler with ice packs.

INORGANIC ANALYSES

Analysis	Emergency Min. Vol(ml)	Container	Preservative	Type	HoldTime	Notes
Alkalinity (caustic,carbonate)	200	500ml (P)	No Pres	Comp	14 days	
BOD	500	1L (P)	No Pres	Comp	48 hrs	If all analyses
Bromide	100	500ml (P)	No Pres	Comp	28 days	are required
Chloride	100	500ml (P)	No Pres	Comp	28 days	take 2 Qts
Fluoride	100	500ml (P)	No Pres	Comp	28 days	
Sulfate	200	500ml (P)	No Pres	Comp	28 days	
Surfactants	200	500ml (P)	No Pres	Comp	48 hrs	
TSS, TS, TDS	200, 200, 200	1L (P)	No Pres	Comp	7 days	
Setteable Solids	1000	1L (P)	No Pres	Grab	7 days	
Ammonia	500	1L (P)	H_2SO_4 1/2 squirt pH<2	Grab	28 days	If all analyses
TKN	500	1L (P)	H_2SO_4 1/2 squirt pH<2	Grab	28 days	are required
Phosphorous-P (total)	100	500ml (P)	H_2SO_4 1/2 squirt pH<2	Grab	28 days	take 1 Qt
Cyanide (TCN)	100	500ml (P)	NaOH pH>12	Grab	14 days	*1
Cr VI	100	500ml (P)	No Pres	Grab	ASAP	If all analyses
Nitrate, Nitrite	100, 100	500ml (P)	No Pres	Grab	48 hrs	are required
Orthophosphate-P (ortho)	100	500ml (P)	No Pres	Grab	48 hrs	take 1 Qt
Spec. Con.	100	500ml (P)	No Pres	Grab	28 days	
Turbidity	50	500ml (P)	No Pres	Grab	28 days	
PH	50	500ml (P)	No Pres	Grab	ASAP	
Oil & Greas/TPH (4181)	1 L	2x 1L (G)	H_2SO_4 2 squirt pH<2	Grab	28 days	*2
Phenol	500	1L (AG)	H_2SO_4 pH<2	Grab	28 days	*1
Sulfite	100	500ml (P)	EDTA 1 squirt	Grab	ASAP	
Sulfide	100	500ml (P)	ZnAC 1 squirt NaOH 1 squirt pH>9	Grab	7 days	
Bacteria (MF, HPC, P/A)	100	100 ml sterile	No Pres	Grab	30 hrs	*1
Bacteria (MPN)	100	100 ml sterile	No Pres	Grab	6 hrs	
COD	25	500ml (P)	H_2SO_4 1 squirt pH<2	Comp	28 days	
Metals / Hardness	200	500ml (P)	HNO_3 1 squirt pH<2	Comp	6 mo.	
Total Residual Cl	50	(AG)	No Pres		ASAP	

ORGANIC ANALYSES

Analysis	Matrix	Container	Preservative	Type	HoldTime	Notes
Semi-Volatiles	Liquid Solid	1L (G) (T) 125ml (G) (T)	No Pres	Comp	7 days 14 days	*2
Volatiles	Liquid (524.2) Solid	2x40ml vial (T) 3x40ml vial (T) 2 x 40ml	HCl 5 drops pH<2 HCl 5 drops pH<2 MeoH	Grab	14 days	*1
Herbicides	Liquid Solid	1L (G) (T) 125 ml (G) (T)	No Pres No Pres		7 days 14 days	*2
Pest/PCB	Liquid Solid	1L (G) (T) 125ml (G) (T)	No Pres pH 5-9 No Pres	Comp	7 days 14 days	*2
TPH 8100 MADEP EPH	Liquid Liquid	1L (G) (T) (2) 1LAmb (G) (T)	HCl 2 squirts pH<2 HCl 2 squirts pH<2		7 days 14 days	*2 *3
TPH 8100 MADEP EPH	Solid Solid	125ml (G) (T) 125ml (G) (T)	No Pres No Pres		14 days 7 days	
MADEP VPH	Liquid	2x40ml vial (T)	HCl 5 drops pH<2		14 days	
MADEP VPH	Solid	125ml (G) (T)	1ml methanol/g		14 days	*4
Formaldehyde	Liquid Solid	1L (G) (T) 125ml (G)	No Pres No Pres	Grab	3 days	
Propylene Glycol	Liquid	1L (G) (T)	HCl 2 squirts pH<2			

SUB WORK

Analysis	Matrix	Container	Preservative	Type	HoldTime	Notes
Radon	Liquid	Radon Water Kit				
Radon / Gross Alpha	Liquid	Gallon (P) 40 ml vial	No Pres		48 Hours	State of Me
TOC	Liquid	2x 40ml vial	H_2SO_4 5 drops pH<2	Grab	28 Days	
TOC	Solid	125ml (G)	No Pres		28 Days	
Toxicity		Gallon cubes	No Pres		Permit specific	
Dioxin		125ml (G)	No Pres			

COMMON PACKAGE ANALYSES

Analysis	Matrix	Container	Preservative	Type	HoldTime	Notes
NH Virgin Petroleum Contaminated Soil (NH VPCS) (Table IV) (MTS specs) (Asphalt Batching)	Solid	500ml (G)	No Pres			
NH VPCS Certified Non-Hazardous	Solid	250ml (G)	No Pres			
Complete TCEP	Solid	500ml (G)	No Pres			
AMREC Acceptance Package	Solid	500ml (G)	No Pres			
NH DES Tank Closure Table III						
- Gasoline	Liquid	2x40ml vial (T)	HCL			
	Solid	500ml (G)	No Pres			
- Waste Oil	Liquid	2x40ml vial (T) 1L (G) (T)	HCL No Pres			
	Solid	500ml Glass	No Pres			
- Diesel, Kerosene heating	Liquid	2x40ml vial (T) 1L (G) (T)	HCL No Pres			
	Solid	125ml (G)	No Pres			
Specification Used Oil	Solid	250ml (G)	No Pres			
RCRA Waste Characterization Profile	Solid	500ml (G)	No Pres			
TCLP Metals	Solid	500ml (G) 105g min.	No Pres			
RCRA Metal	Solid	125ml (G)				
RCRA Metal	Liquid	500ml (P)	HNO_3 1 squirt pH<2			

$CuSO_4$	Cupric Sulfate	H_3PO_4	Phosphoric Acid	NaOH	Sodium Hydroxide
HCl	Hydrochloric Acid	H_2SO_4	Sulfuric Acid	$Na_2S_2O_3$	Sodium Thiosulfate
HNO_3	Nitric Acid	$C_6H_8O_6$	Ascorbic Acid	ZnAC	Zinc Acetate

1 Squirt ≈ 2.5 ml by disposable plastic eye dropper
***1 Check for presence of and eliminate chlorine prior to preservation. If chlorine is present add the following. DO NOT COMBINE THE DECHLORINATING AGENT AND THE PRESERVATIVE IN THE SAMPLE VIAL PRIOR TO SAMPLING.**

Phenol - ferrous sulfate ($FeSO_4$)
VOA 624, Coliform - sodium thiosulfate ($Na_2S_2O_3$) Recheck before preserving!
VOA 524, Cyanide - ascorbic acid ($C_6H_8O_6$) Recheck before preserving!

***2 Take one duplicate per job**
***3 Take one duplicate per sample ID**
***4 Please see procedure for the preparation of VPH sampling vials and/or the organic department**

(AG) = AMBER GLASS (G) = GLASS (P) = PLASTIC (T) = container must have a teflon liner in the cap

BACTERIOLOGICAL PARAMETERS LISTING

HOLDING TIMES: Recommend beginning analyses within 6 hours

Drinking water (Total Coliforms, Fecal Coliforms, E. coli.) – **30 hours**
(Heterotrophic Plate Count, TPC) – **8 hours**

Source Water (Total Coliforms, Fecal Coliforms) – **8 hours**

All Other Waters - **24 hours**

PARAMETER	**EPA METHOD**	**DETECTION LIMIT**
IRON BACTERIA	SM 9240B	P/A
E. COLI (natural bathing beaches)(MF)	SM 9213D	0 colonies / 100 ml
FECAL COLIFORM (MF)	SM 9222D	0 colonies / 100 ml
FECAL COLIFORM (MPN)	SM 9221E	2 MPN / 100 ml
FECAL STREP (MF)	SM 9230C	0 colonies / 100 ml
TOTAL COLIFORM -TC (MF)	SM 9222B	0 colonies / 100 ml
NON COLIFORM (MF)	SM 9222B	0 colonies / 100 ml
TOTAL COLIFORM (MPN)	SM 9221B	2 MPN / 100 ml
TOTAL COLIFORM (soil) (MPN)	SM 9221B M	2 MPN / gram / 100 ml
TOTAL PLATE COUNT (pour plate method) (heterotrophic plate count)	SM 9215B SM 9215B M (soil)	0 CFU / ml 100 CFU / gram

DRINKING WATER ONLY		
TOTAL (P/A)	SM 9223B	P/A
E-COLI (P/A)	SM 9223B	P/A
TOTAL COLIFORM (MPN)	SM 9223B	2 MPN / 100 ml
E. COLI (MPN)	SM 9223B	2 MPN / 100 ml

MF = membrane filter
MPN = most probable number
CFU = colony forming units
SM 9223 B = Colilert method

SOLIDS for MF are reported as **colonies / gram / 100ml**

SOLIDS for MPN are reported as **MPN / gram / 100ml**

SOLIDS for Total Plate Count are reported as **CFU / gram**

DRINKING WATER
INORGANIC PARAMETER LISTING

PARAMETER	EPA METHOD #	HOLDING TIME	LIMITS
ALKALINITY	SM 2320B	14 DAYS	1.
BROMIDE	300.0	28 DAYS	1.0
CHLORIDE (CL^-)	300.0	28 DAYS	1.0
COLOR Modified	Screen	48 HOURS	0. (units)
CYANIDE-T (TCN)	SM 4500-CNE / SM 4500-CNF	14 DAYS	0.02
FLUORIDE	300.0	28 DAYS	0.10
HARDNESS	SM 2340B	6 MONTHS	1.
CALCIUM	200.7		0.50
MAGNESIUM	200.7		0.50
HYDROGEN SULFIDE S^{2-}	SM 4500-S^{2-} F	7 DAYS	0.001
NITRATE-N (NO_3)	300.0	48 HOURS	1.0
NITRITE-N (NO_2)	300.0	48 HOURS	0.01
NITRATE-N/NITRITE-N (NO_3 / NO_2)	300.0	48 HOURS 28 D if preserved	1.0
ODOR	Screen	24 HOURS	P/N
pH	150.1	ASAP	0-14 (units)
PHOSPHOROUS-P (total)	365.2	28 DAYS	0.05
ORTHOPHOSPHATE-P	300.0	48 HOURS	0.05
SPECIFIC CONDUCTANCE	SM 2510B	28 DAYS	1. umhos/cm
SULFATE (SO_4)	300.0	28 DAYS	1.0
TEMPERATURE	SM 2550B	ASAP	N/A
TOTAL DISOLVED SOLIDS (TDS)	SM 2540C	7 DAYS	10.
RESIDUAL CHLORINE - FREE	SM 4500-ClG	ASAP	0.1
TURBIDITY (NTU)	180.1	48 HOURS	0.5 NTU
ALUMINUM (Al)	200.7	6 months	0.030
ANTIMONY (Sb)	200.9	6 months	0.006
ARSENIC (As)	200.9	6 months	0.010
BARIUM (Ba)	200.7	6 months	0.010
BERYLLIUM (Be)	200.7	6 months	0.010
CADMIUM (Cd)	200.9	6 months	0.0005
CALCIUM (Ca)	200.7	6 months	0.50
CHROMIUM (Cr)	200.7	6 months	0.010
COPPER (Cu)	200.7	6 months	0.010
IRON (Fe)	200.7	6 months	0.010
LEAD (Pb)	200.9	6 months	0.005
MAGNESIUM (Mg)	200.7	6 months	0.010
MANGANESE (Mn)	200.7	6 months	0.010
MERCURY (Hg)	245.1	6 months	0.0005
NICKEL (Ni)	200.7	6 months	0.010
POTASSIUM (K)	200.7	6 months	0.50
SELENIUM (Se)	200.9	6 months	0.010
SILICA (SiO_2)	200.7	6 months	0.50
SILVER (Ag)	200.7	6 months	0.010
SODIUM (Na)	200.7	6 months	1.0
THALLIUM (Tl)	200.9	6 months	0.002
ZINC (Zn)	200.7	6 months	0.010

MEASURE IN (mg/L) EXCEPT AS NOTED.
Any noted exceptions will be placed in parentheses in the parameter section.
( ) indicates a notation to the user

WASTE WATER / SOLIDS / GROUND WATER
INORGANIC PARAMETER LISTING

PARAMETER	EPA METHOD# Wastewater	Ground water	Solid	HOLD TIME	LIQUID LIMITS	SOLID LIMITS
					mg/L	mg/Kg
ACIDITY	305.1	305.1		14 days	10.	
ALKALINITY	310.1	310.1		14 days	1.	
CAUSTIC ALKALINITY	SM 2320B	SM 2320B		14 days	0.	
ALKALINITY						
HYDROXIDE	SM 2320B	SM 2320B		14 days	0.	
CARBONATE	SM 2320B	SM 2320B		14 days	0.	
BICARBONATE	SM 2320B	SM 2320B		14 days	0.	
AMMONIA -N (NH_3)	350.2	350.2	350.2 M	28 days	0.10	5.00
BOD-5	405.1	405.1		48 hours	1.	
BROMIDE	SM 4500-BrB	SW 9056	SW 9056 M	28 days	0.2 / 1.0	10.
HEAT OF COMBUSTION	ASTM D240-87		ASTM D240-87	N/A	0 (BTU/lb)	
%ASH	ASTM D482-87		ASTM D482-87			
% HALOGENS	SW 5050/9056		SW 5050/9056	N/A	0.10	
% SULFUR-S	SW 5050/9056		SW 5050/9056	N/A	0.10	
CHLORIDE (CL^-)	325.3/300.0	SW 9056	SW 9056 M	28 days	3/1.0 / 1.0	10.
RESIDUAL CHLORINE – TOTAL	330.5	330.5		ASAP	0.2	
RESIDUAL CHLORINE – FREE	SM 4500-Cl G	SM 4500-Cl G		ASAP	0.2	
C-BOD-5	SM 5210 B			48 hours	1.	
CHROMIUM VI	SM 3500-CrD	SM 3500-CrD	SM 3500-CrD M	24 hours	0.02	0.2
COD	410.4	410.4		28 days	8.	
COLOR	110.2	110.2		48 hours	0 (units)	
CORROSIVITY-Ph			SW 9045C	ASAP		0-14 (units)
CYANIDE-T (TCN)	335.2	SW 9010B/ 9014	SW 9010B/9014 M	14 days	0.02	0.75
CYANIDE-ATCL (AMENABLE)	335.1	SW 9010B/ 9014	SW 9010B/9014 M	14 days	0.02	0.75
DENSITY			N/A	N/A		N/A (g/cc)
DISSOLVED OXYGEN (DO)	360.1	360.1		ASAP	N/A	
FLASHPOINT (Ignitability)	SW 1010		SW 1010 M	14 days	40° F	40° F
FLUORIDE		SW 9056	SW 9056 M	28 days	0.10	1.0
HARDNESS CALCIUM MAGNESIUM	SM 2340B 200.7 200.7	SM 2340B 6010 6010		6 months	1.0 0.50 0.50	
HYDROGEN SULFIDE S^{2-}	SM 4500-S^{2-} F	SM 4500-S^{2-} F			0.1	
KJELDAHL-N (TKN)	351.3	351.3	351.3 M	28 days	0.10	5.00
NITRATE-N (NO_3)	300.0	SW 9056	SW 9056 M	48 hours	1.000	10.
NITRITE-N (NO_2^-)	300.0	SW 9056	SW 9056 M	48 hours	0.01	0.5
NITRATE-N/NITRITE-N	300.0	SW 9056	SW 9056 M	48 hours 28 days	1.00 if preserved	10.
ODOR	SCREEN	SCREEN		24 hours	P/N	
OIL & GREASE (grav)	1664	1664		28 days	5.	
* OIL & GREASE SOX (grav)			SW 9071A	28 days	5.	

MEASURE IN (mg/L) EXCEPT AS NOTED.
Any noted exceptions will be placed in parentheses in the parameter section.

*** BASED ON DRY WEIGHT (add % moisture to worksheet)**
**** mg/L MBAS calculated as LAS, Mol wt 318**

ALL SOLIDS RUN USING A LIQUID METHOD WILL BE NOTED BY A "M" AFTER THE METHOD. ex. 335.2 M

( ) indicates a notation to the user

WASTE WATER / SOLIDS / GROUND WATER
INORGANIC PARAMETER LISTING

PARAMETER	EPA METHOD# Wastewater	Ground water	Solid	HOLD TIME	LIQUID LIMITS	SOLID LIMITS
					mg/L	mg/Kg
PAINT FILTER			SW 9095	N/A		P/N
pH	150.1	150.1		ASAP	0-14 (units)	
PHENOL (5 ppb)	420.1	SW 9065		28 days	0.005	
PHENOL (50 ppb)	420.1	SW 9065	SW 9065 M	28 days	0.05	
PHOSPHOROUS-P (total)	365.2	365.2	365.2 M	28 days	0.05	0.25
ORTHOPHOSPHATE-P (ortho)	365.2/300.0	SW 9056	SW 9056 M	48 hours	0.05	0.5
REACTIVITY						
CYANIDE	SW-846 7.3.3.2		SW-846 7.3.3.2/ 9014	N/A		25.
SULFIDE	SW-846 7.3.4.2		SW-846 7.3.4.2/ 376.2	N/A		25.
SPECIFIC CONDUCTANCE	120.1	SW 9050A	SW 9050A M	28 days	1.umhos/cm	1.umhos/cm
SULFATE (SO_4)	375.4/300.0	SW 9056	SW 9056 M	28 days	5/1.0 /1.0	25.
SULFIDE (H_2S)	376.2	376.2	376.2 M	7 days	0.1	1.0
SULFITE	377.1	377.1	377.1 M	ASAP	2.	20.
**SURFACTANTS (as MBAS)	425.1	425.1		48 hours	0.025	
TEMPERATURE	170.1	170.1		ASAP	N/A	N/A
TOTAL ORGANIC NITROGEN-N	351.3	351.3	351.3 M	28 days	0.10	5.00
* TPH SOX			SW 9071A M	28 days		
TURBIDITY (NTU)	180.1	180.1		48 hours	0.5 NTU	

SOLIDS on Liquids						
TDS (TOTAL DISSOLVED)	160.1	160.1		7 days	10.	
TS (TOTAL SOLIDS)	160.3	160.3		7 days	10.	
TOTAL SETTLEABLE	160.5	160.5		48 hours	0.20ml/L	
TSS (TOTAL SUSPENDED)	160.2	160.2		7 days	4.	
TVS (TOTAL VOLATILE)	160.4	160.4		7 days	10.	

SOLIDS						
% Moisture			SM 2540G	7 days		N/A
% Total Solids			SM 2540G	7 days		N/A
% Volatile Solids			SM 2540G	7 days		N/A
% Fixed Solids			SM 2540G	7 days		N/A

FIELD READINGS						
pH	150.1	150.1		on site	0-14	
RESIDUAL CHLORINE - TOTAL	HACH	HACH		on site	0.01	
SPECIFIC CONDUCTANCE	120.1	120.1		on site	10. umhos/cm	
TEMPERATURE	SM 2550B	SM 2550B		on site	N/A	

MEASURED IN (mg/L) EXCEPT AS NOTED.
Any noted exceptions will be placed in parentheses in the parameter section.

*** BASED ON DRY WEIGHT (add % moisture to worksheet)**
**** mg/L MBAS calculated as LAS, Mol wt 318**

ALL SOLIDS RUN USING A LIQUID METHOD WILL BE NOTED BY A "M" AFTER THE METHOD. ex. 335.2 M

( ) indicates a notation to the user

ORGANIC PARAMETER LISTING

Acid/Base/Neutral Extractables (A,B,N) (625/8270)
(Semi-Volatile Compounds)

Acid Extractables (625/8270)

Base/Neutral Extractables (625/8270)

BTEX/TPH (Modified 8015)

Extractable Petroleum Hydrocarbons (MA DEP EPH)

Formaldehyde (8315)

Herbicides (8151A)

PAH/TPH (Modified 8100)

PCB's (in oil)

PCB's (608/8082)

PCB

PCB's/Pesticides (608/8081/8082)

Pesticides (608/8081)

PolyNuclear Aromatic Hydrocarbons (PAH) (625/8270)

Total Petroleum Hydrocarbons (TPH) (Modified 8015)

Total Petroleum Hydrocarbons (TPH) (Modified 8100)

Volatile Aromatics (BTEX) (602/624/8020/8260)

Volatile Halocarbons (601/624/8010/8260)

Volatile Petroleum Hydrocarbons (MA DEP VPH)

Volatile Organics (624/8260)

E-TPH (Combination MA DEP EPH & VPH)

ATTACHMENT #7

SOP NUMBER	METHOD	REV. DATE	REV. NUMBER	DESCRIPTION
AA001	200.7 1982	03/19/04	0.6	Determination of Metals in Drinking water, water and waste water by ICP.
AA002	6010	07/08/02	0.1	Determination of Metals by ICP
GN003	335.2	8/19/2003	0.4	Determination of Cyanide
AA004	245.1	12/18/03	0.4	Determination of Mercury by Manual Cold Vapor
GN004	300.0	1/26/05	0.7	Determination of Inorganic Anions by Ion Chromatography
GN007	150.1	10/03/02	0.2	Determination of pH by Electrode
OP008		11/22/98	0	Standard Operation Procedures for Laboratory Balances.
GN009	9222B SM18th	10/29/02	0.3	Membrane Filtration for members of the Coliform Group
GC010	EPA 552.2	2/3/99	0	Determination of Haloacetic Acids in Drinking water by ECD.
GN011	9222D Sm18th	12/02/02	0.4	Fecal Coliform bacteria by Membrane Filtration
GN012	9213D SM18th	2/4/99	0.1	E-coli by Membrane Filtration for Natural Bathing Beaches
GN013	160.2	11/07/02	0.3	Determination of Total Suspended Solids
GC014	EPA 552.1 Rev.1.0 1992	2/4/99	0	Determination of Haloacetic acids in drinking water by micro disk extraction.
GN015	9223B Sm18th.	11/01/02	0.3	Coliform-MPN by Colilert multiple tube fermentation.
GN016	180.1 EPA	6/19/03	0.4	Determination of Turbidity
AA017	7000	12/03/01	0.1	Metals by GFAA
GC018	SW-846-8011	02/06/02	0.2	Determination of EDB
GN019	160.1 EPA	7/8/03	0.4	Determination of Total Dissolved Solids (TDS)
GN020	SW-846 1311	01/26/05	0.2	TCLP extraction
GN021	305.1 EPA	11/26/01	0.2	Determination of Acidity
GN022	310.1 EPA	06/30/04	0.5	Determination of Alkalinity
GN023	405.1	12/11/03	0.6	Determination of BOD
GN024	325.3 EPA	12/11/03	0.6	Determination of Chloride
GN025	330.5 EPA SM4500-Cl G	7/22/03	0.4	Determination of Residual Free Chlorine
GN026	330.5 EPA SM4500-Cl G	7/22/03	0.4	Determination of Total Residual Chlorine
GC027	MADEP EPH	08/20/03	0.3	Determination of Extractable Petroleum Hydrocarbons (EPH)
GN028	SM3500-Cr D	2/10/2005	0.5	Determination of Hexavalent Chromium – HACH
GN029	410.4 EPA SM5220D	3/17/04	0.6	Determination of Chemical Oxygen Demand
GN030	SM2340B EPA 200.7	11/12/02	0.3	Determination of Hardness

SOP NUMBER	METHOD	REV. DATE	REV. NUMBER	DESCRIPTION
GN031	SW846 1010	12/18/01	0.2	Determination of Flashpoint
GN032	EPA 350.2 SM4500-NH_3 B,C	12/11/03	0.5	Determination of Nitrogen –Ammonia
GC033	SW846 8015	05/57/99	0.0	Determination of Alcohols by 8015 direct inject.
GN034	EPA1664	01/27/04	0.8	Determination of HEM (O&G) and SGT-HEM (non polar material) by extraction and gravimetry.
GN035	EPA420.1&S M5530C,D	8/25/03	0.6	Determination of Phenols Spectrophotometer with distillation.
GN036	EPA365.2	12/11/03	0.6	Determination of Total Phosphorous
GN037	SM9215B	3/19/04	0.4	Determination of Heterotrophic Plate Count
GN038	SM9223B	02/26/02	0.3	Determination of Total coliform and e-coli by colilert Presence absence
GN039	SM9221B&E	02/26/02	0.2	Determination of Total/Fecal coliform Most Probably Number(MPN) by Multiple Tube Fermentation in Waste Water
GN040	EPA 375.4 SM4500-SO_4	11/25/02	0.4	Determination of Sulfate-Turbimetric
GN041	EPA 351.3	8/19/03	0.7	Determination of Total Kjeldahl Nitrogen.
OP042	3660B		0.0	Sulfer Cleanup of PCP/Pest.
OP043	SW8151A	10/03/00	0.2	Herbicide Extraction soil & water.
OP044	SW 3550	02/22/05	0.4	Ultra-Sonic extraction of Solids for PCB's.
OP045	SW3510C	10/03/00	0.2	Aqueous Extraction of PCB's
OP046	SW 8100/3550	02/18/05	0.4	8100 Prep by 3550, soil and liquid.
OP047	SW8270/3550	2/18/05	0.5	Extraction of BNA samples, solid and liquid.
OP048	SW8315A	08/07/02	0.6	Extraction of Formaldehyde
GN049	ASTM 240D	04/05/01	0.2	Heat of Combustion - BTU
GC050	SW8270C	11/17/99	0.1	Analysis of Semivolatile compounds by 8270C.
GC051	SW8260	11/18/99	0.1	Analysis of Volatile compounds by 8260B.
GN052	EPA 376.2	12/11/03	0.4	Determination of Sulfide
GN053	EPA 377.1	02/03/03	0.3	Determination of Sulfite
GN054	EPA 425.1	10/06/03	0.4	Determination of Surfactants (MBAS)
	SM 9050	10/96		Preparation of Buffered Water
		10/96		Preparation of Confirmatory Broths
GN055	SM9230C	01/31/00	0.1	Determination of Fecal Stroptococcus
		10/96		Quality Control for Micro Supplies
GN057	EPA 335.1	08/09/03	0.3	Determination of Amenable Cyanide
	SM2330B	2/97		Langlier Index
GN060	EPA 354.1	No longer in use		Determination of Nitrites in waste water

SOP NUMBER	METHOD	REV. DATE	REV. NUMBER	DESCRIPTION
	EPA140.1	9/97		Determination of Odor
	EPA 413.1	5/98		Determination of Oil and Grease
	EPA 418.1	9/97		Determination of Total Petroleum Hydrocarbons
GN062	SW 9095A	2/29/00	0.1	Paint Filter Liquids
GN056	EPA120.1	8/7/03	0.4	Determination of Specific Conductance
GN061	SW 7.3.4.2	7/11/03	0.2	Determination of Reactivity – Sulfide
GN063	SW 7.3.3.2	03/01/00	0.1	Determination of Reactivity - Cyanide
GN059	EPA 160.5	10/29/02	0.3	Settleable Solids
GN058	EPA 160.3	10/17/03	0.4	Total Solids Residue
	EPA 160.4	4/98		Total Volatile Solids
		4/98		Dissolved Metals Sample Prep.
AA071	SW 3050	01/261/05	0.4	Hot Plate Digestion for Metals-Solids
AA072	SW 3051	01/14/03	0.4	Microwave digestion for metals – solid
AA073	SW 3015	01/26/05	0.2	Mircrowave digestion for metals – liquids
	SW1310	9/97		Extraction Procedure Toxicity (EPTox)
GC066	EPA 524.2	7/28/03	0.4	Volatile Organic Compounds in Drinking Water
GC067	EPA 624	7/25/03	0.3	Volatile Organics
	SW1311	11/98		Zero Headspace Extraction for Volatile TCLP
	MADEP-VPH	11/98		Determination Volatile Petroleum Hydrocarbons – Mass. DEP.
GC068	EPA 625	06/28/02	0.2	Determination of Semi-Volatile Organic Compounds
GC069	EPA 608	7/15/03	0.2	Determination of Pesticides/PCBs
GC064	SW 8081A	03/00	0.1	Determination of Pesticides
GC065	SW 8082	03/00	0.1	Determination of PCB's
GC077	SW 8151A	11/98		Determination of Herbicides
	SW 8100	11/98		Determination of Total Petroleum Hydrocarbons
	SW 8015B	11/98		Determination of Total Petroleum Hydrocarbons as gasoline
GC070	SW 8315A	04/00		Determination of Formaldehyde
OP074	SW 3550 & 3510	05/18/00		Extraction of PAH for Soil and water for HPLC
GC075	SW8310	05/18/00		Analysis of PAH by HPCL by 8310
AA076	EPA 245.1, SW 7470	05/25/00	Archived 9/17/02	Digestion of Mercy in Aqueous samples.
QC0077		07/10/00	0	Calibration of Pipettors and laboratory glassware.
QC0078		07/18/00	0	Calibration of Thermometers.
OP0079				
GC0080		09/30/00	01	VOA Analysis by GC-FID Direct Inject
GC0081	Mod. 8315	10/25/00	0	Determination of Rubrene by HPLC
QC0082		3/24/04	0.1	Control of Laboratory Consumable Materials

SOP NUMBER	METHOD	REV. DATE	REV. NUMBER	DESCRIPTION
QC0083		12/29/00	0	Subsampling from Submitted samples.
QC0084		12/29/00	0	Disposal of Samples
AA0085	EPA 200.7	01/26/05	0.4	Hot Plate Digestion of Liquid Samples.
GN0086	EPA 24	03/09/01	0	Determination of Volatile Matter content, Water content, Density and Weight solids of surface coatings.
OP0087	EPA 608	9/11/03	0.2	Aqueous Extraction of PCB's and Pesticides by 608.
GN088	SM 9050	01/10/02	0	Preparation of Buffered water
GN089	SM 9020	01/10/02	0	Preparation of Confirmatory Broths.
GN090	SM 9020	3/23/04	0.1	Quality Control for Microbiology Supplies
QC0091		01/29/02	0	Investigation into Data Quality
QC0092	EPA314.0	08/05/02	0	Determination of Perchlorates
QC0093.		09/09/02	0	SOP on writing and revising SOP's
AA0094	SW7471	12/11/03	1	Determination of Mercury in Solids
QC0095		01/20/03	0	Guidelines for Manual Calculations and Manual Integration
GN096	SW 1030	08/13/03	0	Ignitability of Solids
GN097				Ammonia Probe method
QC098		11/13/03	0	Washing Glassware
GN099	314.0	009/28/04	0.5	MADEP Perchlorate by Ion Chromatography
GN100	EPA 1103.1	02/22/05	0.1	Ecoli by Membrane Filtration for Bathing Beaches
OP101	515.2	04/12/04	0	Extraction of Herbicides by SPE cartridges
OP102	549.1	04/13/04	0	Extraction of Diquat by SPE cartridges
GN103	2540E	02/01/05	0	Total Volatile Solids

Last updated 03/05

ATTACHMENT #8

317 Elm Street
Milford NH 03055
Tel (603) 673-5440
Fax (603) 673-0366

DEMONSTRATION OF CAPABILITY CERTIFICATION STATEMENT

DATE:
CHEMSERVE
317 Elm Street
Milford, NH 03055

ANALYST:
MATRIX:
METHOD:

We, the undersigned, Certify that:

1. The analysts identified above, using the cited method which is in use at this facility for the analysis of samples under the National Environmental Laboratory Accreditation Program, have met the Demonstration of Capability.
2. The test method was performed by the analyst identified on this certificate.
3. A copy of the test method and the laboratory specific SOP are available for all personnel on site.
4. The data associated with the demonstration capability are true, accurate, complete and self-explanatory.
5. All raw data (including a copy of this certification form) necessary to reconstruct and validate these analyses have been retained at the facility, and that the associated information is well organized and available for review by authorized assessors.

Paul Fyfe		
Department Manager's Name and Title	Signature	Date
Ellen Abrams		
Quality Assurance Officer's Name	Signature	Date

ChemServe ENVIRONMENTAL ANALYSTS

PRECISION AND ACCURACY STUDY

Certification or Recertification *(Circle one)*

(**NOTE**If a Spread Sheet is Attached, Mark "S" on listed items.)
COT Attached/Annual Update (Circle one)

Analyst: _____ Instrument: _____

Method #: _____ SOP #: _____

Matrix: _____ Date(s) of Analysis: _____

Results: Analyte _____

True Value QC Check Sample (units): _____

Replicates (units):		%Recovery	
1.	_____	1.	_____
2.	_____	2.	_____
3.	_____	3.	_____
4.	_____	4.	_____
(extra)	_____	(extra)	_____
(extra)	_____	(extra)	_____
(extra)	_____	(extra)	_____
(extra)	_____	(extra)	_____
		Ave. % Rec.	_____

Standard Deviation _____

Control Limits Met: Yes / No

Limits Attached or _____-_____%Rec, _____%RPD / RSD

Lab Complete Date ___/___/___ Analyst's Signature_____

Manager Approval Date ___/___/___ Manager's Signature_____

Certification Period: _____ to _____

Comments:

_____

_____

317 Elm Street Milford, NH 03055 (603)673-5440 Fax-(603)673-0366 Email-chemserv@bit-net.com

STATE CERTIFICATES

State of New Hampshire
Environmental Laboratory Accreditation Program

Awards Primary Accreditation to

Chemserve, Inc.
of
Milford, NH

For the analyses listed on the attached page(s) in accordance with the provisions of the NELAC Standards and Env-C 300.

Certificate Number: 100804

Date of Issue: December 3, 2004

Expiration Date: December 2, 2005

Bill Hall
Program Manager

Method accreditation does not imply acceptable for compliance testing.
Laboratory is required to use EPA approved methods where required by regulation.
Continuing accreditation status is dependent on successful ongoing participation in the program.
Customers may verify the laboratory's current accreditation status by calling (603) 271-2998.

NEW HAMPSHIRE ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM

Chemserve, Inc., 317 Elm Street, Milford, NH 03055 (603) 673-5440
Analyte List Number: 100804-E Date of Issue: January 29, 2005 Expiration Date: December 2, 2005

GRANTS PRIMARY ACCREDITATION TO THE ABOVE MENTIONED LABORATORY FOR THE FOLLOWING ANALYSES:

Drinking Water Microbiology

Escherichia coli	Colilert	SM9223B
Heterotrophic plate count	HPC	SM9215B
Total coliforms	MF	SM9222B
Total coliforms	Colilert	SM9223B

Drinking Water Metals

Aluminum	ICP-AES	EPA 200.7, Rev. 4.4
Antimony	ICP-AES	EPA 200.7, Rev. 4.4
Antimony	GFAAS	EPA 200.9, Rev. 2.2
Arsenic	ICP-AES	EPA 200.7, Rev. 4.4
Arsenic	GFAAS	EPA 200.9, Rev. 2.2
Barium	ICP-AES	EPA 200.7, Rev. 4.4
Beryllium	ICP-AES	EPA 200.7, Rev. 4.4
Boron	ICP-AES	EPA 200.7, Rev. 4.4
Cadmium	ICP-AES	EPA 200.7, Rev. 4.4
Cadmium	GFAAS	EPA 200.9, Rev. 2.2
Calcium	ICP-AES	EPA 200.7, Rev. 4.4
Chromium	ICP-AES	EPA 200.7, Rev. 4.4
Copper	ICP-AES	EPA 200.7, Rev. 4.4
Iron	ICP-AES	EPA 200.7, Rev. 4.4
Lead	ICP-AES	EPA 200.7, Rev. 4.4
Lead	GFAAS	EPA 200.9, Rev. 2.2
Magnesium	ICP-AES	EPA 200.7, Rev. 4.4
Manganese	ICP-AES	EPA 200.7, Rev. 4.4
Mercury	CVAAS	EPA 245.1
Molybdenum	ICP-AES	EPA 200.7, Rev. 4.4
Nickel	ICP-AES	EPA 200.7, Rev. 4.4
Selenium	GFAAS	EPA 200.9, Rev. 2.2
Silver	ICP-AES	EPA 200.7, Rev. 4.4
Sodium	ICP-AES	EPA 200.7, Rev. 4.4
Thallium	GFAAS	EPA 200.9, Rev. 2.2
Vanadium	ICP-AES	EPA 200.7, Rev. 4.4
Zinc	ICP-AES	EPA 200.7, Rev. 4.4

Drinking Water Inorganics

Alkalinity	POT	SM 2320 B
Chloride	COND	EPA 300.0
Chlorine, Total Residual	COLOR	SM 4500 CL
Cyanide, Total	COLOR	SM 4500CN-I
Fluoride	COND	EPA 300.0
Hardness as CaCO3	CALC	SM 2340 B

Drinking Water Inorganics

Nitrate as N	COND	EPA 300.0
Nitrate-Nitrite, Total	COND	EPA 300.0
Nitrite as N	COND	EPA 300.0
Orthophosphate	COLOR	EPA 365.2
pH	POT	EPA 150.1
Solids, Total Dissolved (TDS)	GRAV	SM 2540 C
Specific conductance	COND	EPA 120.1
Specific conductance	COND	SM 2510 B
Sulfate	COND	EPA 300.0
Turbidity	COLOR	EPA 180.1

Drinking Water Trihalomethanes

Bromodichloromethane	GC-MS	EPA 524.2

Drinking Water Regulated Volatile Organics

1,1,1-Trichloroethane	GC-MS	EPA 524.2
1,1,2- Trichloroethane	GC-MS	EPA 524.2
1,1-Dichloroethene	GC-MS	EPA 524.2
1,2,4-Trichlorobenzene	GC-MS	EPA 524.2
1,2-Dichlorobenzene	GC-MS	EPA 524.2
1,2-Dichloroethane	GC-MS	EPA 524.2
1,2-Dichloropropane	GC-MS	EPA 524.2
1,4-Dichlorobenzene	GC-MS	EPA 524.2
Benzene	GC-MS	EPA 524.2
Carbon tetrachloride	GC-MS	EPA 524.2
Chlorobenzene	GC-MS	EPA 524.2
cis-1,2-Dichloroethene	GC-MS	EPA 524.2
Dichloromethane (Methylene chloride)	GC-MS	EPA 524.2
Ethylbenzene	GC-MS	EPA 524.2
Methyl tert-Butyl Ether (MTBE)	GC-MS	EPA 524.2
Styrene	GC-MS	EPA 524.2
Tetrachloroethene	GC-MS	EPA 524.2
Toluene	GC-MS	EPA 524.2
trans-1,2-Dichloroethene	GC-MS	EPA 524.2
Trichloroethene	GC-MS	EPA 524.2
Vinyl chloride	GC-MS	EPA 524.2
Xylenes, Total	GC-MS	EPA 524.2

Drinking Water Unregulated Volatile Organics

1,1,1,2- Tetrachloroethane	GC-MS	EPA 524.2
1,1,2,2- Tetrachloroethane	GC-MS	EPA 524.2
1,1-Dichloroethane	GC-MS	EPA 524.2
1,1-Dichloropropene	GC-MS	EPA 524.2
1,2,3-Trichlorobenzene	GC-MS	EPA 524.2
1,2,4-Trimethylbenzene	GC-MS	EPA 524.2
1,3,5- Trimethylbenzene	GC-MS	EPA 524.2
1,3-Dichlorobenzene	GC-MS	EPA 524.2
1,3- Dichloropropane	GC-MS	EPA 524.2
2-Chlorotoluene	GC-MS	EPA 524.2
4-Chlorotoluene	GC-MS	EPA 524.2
4- Isopropyltoluene	GC-MS	EPA 524.2
Bromobenzene	GC-MS	EPA 524.2
Bromochloromethane	GC-MS	EPA 524.2
Bromomethane	GC-MS	EPA 524.2
Chloroethane	GC-MS	EPA 524.2
Chloromethane	GC-MS	EPA 524.2
cis-1,3- Dichloropropene	GC-MS	EPA 524.2
Dibromomethane	GC-MS	EPA 524.2
Hexachlorobutadiene	GC-MS	EPA 524.2
n- Butylbenzene	GC-MS	EPA 524.2
n- Propylbenzene	GC-MS	EPA 524.2
sec- Butylbenzene	GC-MS	EPA 524.2
tert- Butylbenzene	GC-MS	EPA 524.2
trans-1,3- Dichloropropene	GC-MS	EPA 524.2
Trichlorofluoromethane	GC-MS	EPA 524.2
1,2,3-Trichloropropane	GC-MS	EPA 524.2

Drinking Water Trihalomethanes

Bromodichloromethane	GC-MS	EPA 524.2
Bromoform	GC-MS	EPA 524.2
Chlorodibromomethane	GC-MS	EPA 524.2
Chloroform	GC-MS	EPA 524.2
Total Trihalomethanes	GC-MS	EPA 524.2

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Senator William X. Wall Experiment Station

MITT ROMNEY
Governor

KERRY HEALEY
Lieutenant Governor

ELLEN ROY HERZFELDER
Secretary

ROBERT W. GOLLEDGE, Jr.
Commissioner

March 12, 2004

Mr. Jay W. Chrystal, Laboratory Director
ChemServe
317 Elm Street
Milford, NH 03055

Dear Mr. Chrystal:

This letter serves as notification that the Massachusetts Department of Environmental Protection (DEP) is granting your laboratory **APPROVAL** to analyze potable water samples for low-level perchlorate under the DEP Drinking Water Program's emergency perchlorate regulations at 310 CMR 22.06D. The effective date of this approval is March 12, 2004.

This approval is contingent upon your laboratory continuing to meet the requirements for approval as specified in the DEP Laboratory Certification Office (LCO) letter dated February 18, 2004. When conducting analyses under this approval, your laboratory must meet and fully document all quality control requirements that are specified in the LCO letter of February 18th.

This letter may be presented to any Massachusetts Public Water System (PWS) as evidence of laboratory approval for perchlorate analysis in support of the emergency perchlorate regulations at 310 CMR 22.06D.

If you have any questions on this matter, please contact John J. Bardzik, Laboratory Certification Officer, at 978-682-5237 ext. 331 or by e-mail at John.Bardzik@state.ma.us.

Sincerely,

Oscar C. Pancorbo, Ph.D.
Division and Station Director
Division of Environmental Analysis
Senator William X. Wall Experiment Station

cc: David Y. Terry, Director, Drinking Water Program, BRP, DEP, Boston
Damon Guterman, Drinking Water Program, BRP, DEP, Boston

The Commonwealth of Massachusetts

Department of Environmental Protection

Division of Environmental Analysis
Senator William X. Wall Experiment Station

certifies

M-NH023 CHEMSERVE
317 ELM ST
MILFORD, NH 03055-0000

Laboratory Director: Jay W. Crystal

for the analysis of NON POTABLE WATER (CHEMISTRY)
POTABLE WATER (CHEMISTRY)
POTABLE WATER (MICROBIOLOGY)
pursuant to 310 CMR 42.00

This certificate supersedes all previous Massachusetts certificates issued to this laboratory. The laboratory is regulated by and shall be responsible for being in compliance with Massachusetts regulations at 310 CMR 42.00.

This certificate is valid only when accompanied by the latest dated Certified Parameter List as issued by the Massachusetts D.E.P. Contact the Division of Environmental Analysis to verify the current certification status of the laboratory.

Certification is no guarantee of the validity of the data. This certification is subject to unannounced laboratory inspections.

Issued: 01 JUL 2004
Expires: 30 JUN 2005

Director, Division of Environmental Analysis

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Certified Parameter List as of: 18 FEB 2005

M-NH023 CHEMSERVE
MILFORD NH

NON POTABLE WATER (CHEMISTRY) Effective Date 13 FEB 2005 Expiration Date 30 JUN 2005

Analytes and Methods

ALUMINUM	EPA 200.7	DIELDRIN	EPA 608
ANTIMONY	EPA 200.7	DDD	EPA 608
ARSENIC	EPA 200.7	DDE	EPA 608
BERYLLIUM	EPA 200.7	DDT	EPA 608
CADMIUM	EPA 200.7	HEPTACHLOR	EPA 608
CHROMIUM	EPA 200.7	HEPTACHLOR EPOXIDE	EPA 608
COBALT	EPA 200.7	POLYCHLORINATED BIPHENYLS (WATEF	EPA 608
COPPER	EPA 200.7		
IRON	EPA 200.7		
LEAD	EPA 200.7		
MANGANESE	EPA 200.7		
MERCURY	EPA 245.1		
MOLYBDENUM	EPA 200.7		
NICKEL	EPA 200.7		
SELENIUM	EPA 200.7		
SILVER	EPA 200.7		
THALLIUM	EPA 200.7		
TITANIUM	EPA 200.7		
VANADIUM	EPA 200.7		
ZINC	EPA 200.7		
PH	EPA 150.1		
SPECIFIC CONDUCTIVITY	EPA 120.1		
TOTAL DISSOLVED SOLIDS	EPA 160.1		
TOTAL HARDNESS (CACO3)	SM 2340B		
CALCIUM	EPA 200.7		
MAGNESIUM	EPA 200.7		
SODIUM	EPA 200.7		
POTASSIUM	EPA 200.7		
TOTAL ALKALINITY	SM 2320B		
SULFATE	EPA 300.0		
NITRATE-N	EPA 300.0		
KJELDAHL-N	EPA 351.3		
ORTHOPHOSPHATE	EPA 365.2		
CHEMICAL OXYGEN DEMAND	EPA 410.4		
BIOCHEMICAL OXYGEN DEMAND	EPA 405.1		
NON-FILTERABLE RESIDUE	EPA 160.2		
OIL AND GREASE	EPA 1664		
TOTAL PHENOLICS	EPA 420.1		
VOLATILE HALOCARBONS	EPA 624		
VOLATILE AROMATICS	EPA 624		
CHLORDANE	EPA 608		
ALDRIN	EPA 608		

State of Maine
Department of Health & Human Services
12 State House Station
Augusta, Maine
04333-0012

John Elias Baldacci
Governor

John R. Nicholas
Commissioner

Laboratory ID: NH0023 Date of Issue: 9/10/2004 Expiration Date: 9/10/2005

Chemserve (603) 673-5440

317 Elm Street Milford NH 03055

Has demonstrated the capability to analyze DRINKING WATER analytes as defined by the 22 M.R.S.A., Chapter 157-A and the rules for Comprehensive Environmental Laboratory Certification and the Safe Drinking Water Act is hereby granted CERTIFICATION FOR:

Heterotrophic Plate Count by Pour Plate Count	SM 9215 B	Full Certification
Estimation of Bacterial Density (MPN)	SM 9221 C	Full Certification
Total Coliform - P/A	SM 9221 D	Full Certification
E. Coli EC-MUG	SM 9221 F	Full Certification
Total Coliform MF	SM 9222B	Full Certification
E. Coli - Colilert	SM 9223 B	Full Certification
Total Coliform - Colilert	SM 9223 B	Full Certification
Conductivity	EPA 120.1	Full Certification
pH	EPA 150.1	Full Certification
Total Dissolved Solids (TDS)	EPA 160.1	Full Certification
Turbidity	EPA 180.1	Full Certification
Chloride	EPA 300.0	Full Certification
Fluoride	EPA 300.0	Full Certification
Nitrate	EPA 300.0	Full Certification
Nitrate/Nitrite	EPA 300.0	Full Certification
Nitrite	EPA 300.0	Full Certification
Sulfate	EPA 300.0	Full Certification
ortho-Phosphate as P	EPA 365.2	Full Certification
Alkalinity - Titration Method	SM 2320 B	Full Certification
Hardness by Calculation (CaCO3)	SM 2340 B	Full Certification

This Certificate supercedes all previously issued certificates.

Matthew J. Sica, Certification Officer

DISPLAY IN A PROMINENT POSITION

State of Maine
Department of Health & Human Services
12 State House Station
Augusta, Maine
04333-0012

John Elias Baldacci
Governor

John R. Nicholas
Commissioner

Laboratory ID: NH0023 Date of Issue: 9/10/2004 Expiration Date: 9/10/2005

Chemserve (603) 673-5440

317 Elm Street Milford NH 03055

Has demonstrated the capability to analyze WASTEWATER analytes as defined by the National Pollution Discharge Elimination System and as required by 22 M.R.S.A., Chapter 157-A and the rules for Comprehensive Environmental Laboratory Certification and is hereby granted CERTIFICATION FOR:

Total Coliform - MTF Technique	SM 9221 B	Full Certification
Fecal Coliform - MTF Technique	SM 9221 E	Full Certification
Total Coliform - MF Technique	SM 9222 B	Full Certification
Fecal Coliform - MF Technique	SM 9222 D	Full Certification
Conductance (Specific Conductance)	EPA 120.1	Full Certification
pH	EPA 150.1	Full Certification
Residue, Filterable (TDS)	EPA 160.1	Full Certification
Residue, Non-Filterable (TSS)	EPA 160.2	Full Certification
Residue, Total (TS)	EPA 160.3	Full Certification
Oil & Grease	EPA 1664 A	Full Certification
Chloride	EPA 300.0	Full Certification
Fluoride	EPA 300.0	Full Certification
Nitrogen, Nitrate	EPA 300.0	Full Certification
Sulfate	EPA 300.0	Full Certification
Chlorine, Total Residual	EPA 330.5	Full Certification
Cyanide, Total	EPA 335.2	Full Certification
Nitrogen, Ammonia	EPA 350.2	Full Certification
Nitrogen, Total Kjeldahl	EPA 351.3	Full Certification
ortho-Phosphate	EPA 365.2	Full Certification
Phosphorus, Total	EPA 365.2	Full Certification

This Certificate supercedes all previously issued certificates.

Matthew J. Sica, Certification Officer

DISPLAY IN A PROMINENT POSITION

Full target List Available on Request

HEALTHY VERMONTERS 2010

State of Vermont Department of Health

Drinking Water Laboratory Certification

Chemserve

Milford, NH

Is certified to perform organics analyses on drinking water pursuant to the certification letter dated December 1, 2004.

Commissioner of Health

Laboratory Director

Laboratory Certification Officer

December 1, 2004
Date certified

VT 100803
Laboratory Number

December 1, 2005
Certificate expiration date

State of Connecticut, Department of Public Health

Approved Environmental Laboratory

THIS IS TO CERTIFY THAT THE LABORATORY DESCRIBED BELOW HAS BEEN APPROVED BY THE STATE DEPARTMENT OF PUBLIC HEALTH PURSUANT TO APPLICABLE PROVISIONS OF THE PUBLIC HEALTH CODE AND GENERAL STATUTES OF CONNECTICUT, FOR MAKING THE EXAMINATIONS, DETERMINATIONS OR TESTS SPECIFIED BELOW WHICH HAVE BEEN AUTHORIZED IN WRITING BY THAT DEPARTMENT.

CHEMSERVE

LOCATED AT 317 ELM STREET IN MILFORD, NH 03055

AND REGISTERED IN THE NAME OF JAY W. CHRYSTAL

THIS CERTIFICATE IS ISSUED IN THE NAME OF JAY W. CHRYSTAL WHO HAS BEEN DESIGNATED BY THE REGISTERED OWNER/AUTHORIZED AGENT TO BE IN CHARGE OF THE LABORATORY WORK COVERED BY THIS CERTIFICATE OF APPROVAL AS FOLLOWS:

POTABLE WATER, WASTEWATER

Examination For:

BACTERIA

INORGANIC CHEMICALS

ORGANIC CHEMICALS

SEE COMPUTER PRINT-OUT FOR SPECIFIC TESTS APPROVED

THIS CERTIFICATE EXPIRES September 30, 2005 AND IS REVOCABLE FOR CAUSE BY THE STATE DEPARTMENT OF PUBLIC HEALTH

DATED AT HARTFORD, CONNECTICUT, THIS 1st DAY OF October 2003

PH-0793

Ellen J. Blaschinski

DIRECTOR, DIVISION OF ENVIRONMENTAL HEALTH

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

Office of Ground Water and Drinking Water
Technical Support Center

December 04, 2000

Ellen Abrams
ChemServe, Inc.
317 Elm Street
Milford, NH 03055

This letter is to advise you that ChemServe, Inc. has PASSED the Fall 2000 Perchlorate PT Study and has been granted APPROVAL to monitor for perchlorate as an assessment monitoring parameter under the Unregulated Contaminant Monitoring Rule (UCMR). Laboratory approval is contingent upon maintaining certification to perform drinking water compliance monitoring of any inorganic parameter using an approved ion chromatographic method. If a laboratory maintains this certification, the approval to support the assessment monitoring of perchlorate under the UCMR remains active. This letter may be presented to any Public Water System as evidence of laboratory approval for perchlorate analysis supporting the UCMR.

The data reported by your laboratory are presented below in Table 1 along with acceptable performance ranges. Only those laboratories which submitted acceptable results for both matrix conductance and perchlorate concentration passed the Fall 2000 Perchlorate PT study. See Table 2 for a summary of the performance of all laboratories.

Table 1. Fall 2000 Perchlorate PT Study Performance

ChemServe, Inc.

Parameter	Laboratory Reported Result	Fall 2000 Study True Value (TV)	Acceptance Limits (75%- 125% of TV)
Conductivity	680 uS/cm	700 uS/cm	525 uS/cm - 875 uS/cm
Perchlorate	32.1 ug/L	28.0 ug/L	21.0 ug/L - 35.0 ug/L

Rev. Date: 06/29/04
GN022.5
QA/Manager: 6/30/04
Dept. Manager: 6/30/04

TITLE **DETERMINATION OF ALKALINITY**

METHOD: **2320B SM18TH**
EPA 310.1

REFERENCES: **SM 18TH, 2320B, EPA 310.1 Rev.1971**

1.0 SCOPE AND APPLICATION

The Alkalinity of water is its acid-neutralizing capacity. The presence of carbonates, bicarbonates and hydroxides determines the alkalinity. This method is useful for the control of water and wastewater treatment processes.

2.0 SUMMARY OF METHOD

2.1 pH is determined and a measured amount of 0.02N H_2SO_4 solution is added as needed to lower the pH to 4.5. The alkalinity is then calculated based on these numbers

3.0 INTERFERENCES

3.1 Soaps, oily matter and suspended solids may coat the electrode of the pH meter and give a sluggish response. Allow additional time between additions of titrant. Do not filter, dilute concentrate or alter the sample in any way.

3.2 Residual chlorine in samples may bleach the indicator, add a drop of sodium thiosulfate to the sample.

4.0 HEALTH AND SAFETY

Follow all Health and Safety procedures as outlined in the Chemserve Chemical Hygiene Plan. At a minimum a lab coat, safety glasses and gloves will be worn when handling client samples, chemicals or reagents.

5.0 PRESERVATION AND HOLDING TIME

5.1 Sample in a plastic or glass 250ml container. Make sure there is no headspace and cap tightly. Do not open container prior to analysis if not sampled in separate container.

5.2 No preservation is required. Do not let sample become warmer than it's sampling temperature.

5.3 Sample should be stored at 4°C and analyze and no later than 14 days after sampling.

6.0 EQUIPMENT AND REAGENTS

6.1 Volumetric pipettes.

6.2 250 ml beakers.

6.3 pH meter
6.4 Burettes and microburettes
6.5 DI water – The pH should be ≥ 6 and the conductivity should be < 2umhoms/cm.

6.6 Standard Sodium Carbonate solution 0.05N – Dry 3-5g of Na_2CO_3 at 250°C for 4 hours. Cool in a dessicator. Weigh 2.5g and transfer to a 1.0 liter flask. Fill to the mark with DI water, dissolve and mix reagent. Solution is good for 1 week.

6.7 Sodium Carbonate spiking solution 500ppm stock – add 0.500g Na_2CO_3 to 1.0 liter of DI water, dissolve and mix reagent.

6.8 Standard Sulfuric Acid 0.1N – Commercially prepared solutions or dilute 2.8ml concentrated sulfuric acid in 1000 ml DI. Slowly adding the DI water to the Acid. Let cool.

<u>If commercially prepared solutions are used 6.8.1 and 6.9.1 do not need to be done.</u>

6.8.1 Standardize the sulfuric acid against Na_2CO_3 by titrating 40ml of 0.05N Na_2CO_3 with 60ml of DI water to a pH of 5.0. Rinse the electrode into the beaker. Boil gently for 3-5 minutes under a watch glass cover. Cool to room temperature, rinse cover into beaker and finish titrating to the pH inflection point. Calculate the Normality of the Sulfuric Acid.

$$\text{Normality, } N = \frac{A \times B}{53.00 \times C}$$

Where: A = g Na_2CO_3 weighed into standard.
B = ml, Na_2CO_3 taken for titration
C = ml, acid used.

Use the measured normality in further calculations or adjust solution to 0.10N. 1ml = 5.00 mg $CaCO_3$.

6.9 Standard Sulfuric Acid 0.02N – Dilute 200ml 0.1N sulfuric acid in 1000 ml DI. <u>Or</u> commercially prepared solution.

6.9.1 Standardize the sulfuric acid against Na_2CO_3 by titrating 15ml of 0.05N Na_2CO_3 with 60ml of DI water to a pH of 5.0. Rinse the electrode into the beaker. Boil gently for 3-5 minutes under a watch glass cover. Cool to room temperature, rinse cover into beaker and finish titrating to the pH inflection point. Calculate the Normality of the Sulfuric Acid.

$$\text{Normality, } N = \frac{A \times B}{53.00 \times C}$$

Where: A = g Na_2CO_3 weighed into standard.
B = ml, Na_2CO_3 taken for titration
C = ml, acid used.

Use the measured normality in further calculations or adjust solution to 1ml = 1.00 mg $CaCO_3$.

6.10 pH meter

7.0 PROCEDURE

7.1 Add 100ml of sample to a 250ml beaker . Avoid agitating, shaking or mixing the sample. Keep at a constant temperature. Measure and record the initial pH.

7.2 Use 0.02N Sulfuric Acid. If more than 20mls of acid are added to the sample, redo the analysis using 0.1N Sulfuric Acid.

7.3 Add standardized acid in 0.5ml or less increments, such that a pH change of less than 0.2mg/L occurs with each addition. After each addition stir thoroughly but gently with a magnetic stirrer.

7.4 Continue to titrate to a pH of 4.5 ±0.20 units (4.3-4.7units). If the sample result is less than 20mg/L than proceed to 7.4.1.

7.4.1 For alkalinity of <20mg/L (use a microburette) stop the titration at pH 4.3-4.7. Record the volume and the exact pH.

7.4.2 Carefully add additional titrant to reduce the pH exactly 0.3 units. Record the volume used and the new pH on the next line in the logbook. Use both volumes in the calculation of the result.

Calculation

$$\text{Total Alkalinity as mg Bicarbonate /L} = \frac{A \times N \times 50{,}000}{\text{mL sample}}$$

Where:
A = ml Acid titrant used
N = Normality of H_2SO_4

Calculation
Low Alkalinity <20.0 mg/L

$$\text{Total Alkalinity as mg Bicarbonate /L} = \frac{(2B-C) \times N \times 50{,}000}{\text{mL sample}}$$

Where:

B = ml Acid titrant used to reach first pH
C = Total mL of titrant to reach second pH (First &Second titration added together)

N = Normality of H_2SO_4

7.5 Caustic Alkalinity is Hydroxide Alkalinity pH to 8.3(or Phenolpthalien Alkalinity "P') If original sample has a pH of less than 8.3, then caustic =0. If the original sample has a pH of greater than 8.3, bring pH down to 8.3 and record mls of titrant used. Calculate P using the regular Alkalinity calculation. Continue to bring pH down to 4.5. Record mls used and calculate Total alkalinity. Use chart to record final caustic alkalinity.

Result of Titration	Hydroxide alkalinity as $CaCO_3$	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Conc. as $CaCO_3$
P=0	0	0	T
P<1/2T	0	2P	T-2P
P=1/2T	0	2P	0
P>1/2T	2P-T	2(T-P)	0
P=T	T	0	0

P = is phenolphthalien alkalinity (pH down to 8.3)
T = total alkalinity

8.0 QUALITY CONTROL

8.1 Analyze a method blank (MB) with every batch. A batch is designated as 20 samples or the amount of samples analyzed in 24 hours (not to exceed 20 samples).

8.2 Analyze a Matrix Spike/Matrix Spike Dup. sample every 20 samples. See logbook cover for limits.

8.3 Analyze a blank spike(BS) every batch. See cover of logbook for limits. If spike is out of control high and the sample results are less than the detection limit, results may be reported. Otherwise all samples must be reanalyzed with a spike in control.

8.4 Analyze a known sample certified by an outside agency every 20 samples. Sample must fall within limits specified by the agency for that parameter.

9.0 WASTE DISPOSAL

9.1 Return unused portion of sample to its appropriate location in the walk-in refrigerator.

9.2 Put sample aliquot used for the analysis into the disposal bucket. Neutralize as needed.

10.0 DEFINITIONS

10.1 Blank Spike = laboratory control sample = laboratory fortified matrix.

10.2 Method Blank = DI water taken through the analysis.

Rev. Date: 02/04/03
GN097.0
QA/Manager: 2/18/03
Dept. Manager: 2/18/03

TITLE **DETERMINATION OF NITROGEN-AMMONIA**

METHOD: **4500-NH_3 F, C SM18TH**
EPA 350.3

REFERENCES: **SM 18TH, 4500-NH_3 F,C EPA 350.3**

1.0 SCOPE AND APPLICATION

This method covers the determination of ammonia – nitrogen exclusive of total Kjeldahl nitrogen, in drinking water, surface and saline waters, domestic and industrial water. The ammonia is determined using an ion selective probe. Routine calibration procedures will yield a working range of 0.10-10.0 mg/L.

2.0 SUMMARY OF METHOD

The sample is read directly as mg/l NH3-N using an ion selective probe. A 2 point calibration curve is developed to derive the sample concentrations.

3.0 INTERFERENCES

3.1 Aromatic and aliphatic amines are a positive interference. Samples are not distilled for this method because turbidity and color do not interfere, as with the Nesslerazation method.

3.2 Mercury and silver interfere by complexing with ammonia.

3.3 Samples must be at a pH of 11 or greater right before analysis.

3.4 The electrode responds slowly at concentrations under 1mg/L. Use longer immersion times.

4.0 HEALTH AND SAFETY

Follow all Health and Safety procedures as outlined in the Chemserve Chemical Hygiene Plan. At a minimum a lab coat, safety glasses and gloves will be worn when handling client samples, chemicals or reagents.

All waste generated from this analysis must be disposed in the neutralization waste stream.

5.0 PRESERVATION AND HOLDING TIME

5.1 Sample in a plastic 500ml container.

5.2 Sample is preserved with 2ml of conc. sulfuric acid per liter of sample.

5.3 Sample should be stored at 4°C and analyzed within 28 days of sampling.

6.0 EQUIPMENT AND REAGENTS

6.1 Expandable ionAnalyzer, Orion EA-920

6.2 DI water – Ammonia free

6.3 Ammonia specific electrode with membrane

6.4 250ml beakers

6.5 Sodium Hydroxide 10N – 400g NaOH diluted to one liter.

6.6 Stir bars

6.7 Ammonia stock - Add 3.819g anhydrous NH_4Cl to one liter of water. (1mL = 1mg NH_3-N) or 1000 mg/L.

7.0 PROCEDURE

7.1 Calibrate the Ion Analyzer per manufacturer instructions with a 1.00 and 10.0 mg/l standard, respectively. Be sure to add 1.0ml of 10N sodium hydroxide to each standard and sample before analysis. Add additional NAOH if needed to achieve a pH of >11.

7.2 If more than 1.0ml of NAOH is used to adjust the pH of the samples, record the amount used in the logbook.

7.3 After curve is complete, analyze a blank sample and a PQL (or detection limit) sample in the same manner as the standards.

7.4 Analyze the samples in the same manner as the standards and record the result from the Ion Analyzer in the logbook.

7.5 The result is Ammonia-N. If results are needed as Ammonia-NH_3 use the calculation below.

Ammonia –N x 17/14 = Ammonia-NH_3.

8.0 QUALITY CONTROL

8.1 Analyze a blank and blank spike sample with every batch. A batch is designated as 20 samples or the amount of samples analyzed in 24 hours, which ever is less.

8.2 Analyze a Matrix spike and a duplicate sample every 20 samples. See logbook for recovery limits.

8.3 Analyze a known sample certified by an outside agency every batch. Sample must fall within limits specified by the agency for that parameter.

8.4 Analyze a PQL sample every batch. Results should be between 80-120%.

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QA: 1/26/05

TITLE **MICROWAVE ASSISTED ACID DIGESTION FOR LIQUIDS**

METHOD **SW 846 3015B**

REFERENCE: **SW846 3015B 1994**

1.0 Scope and Application

1.1 This method is used for the preparation of aqueous samples, mobility-procedure extracts and wastes that contain suspended solids. Digestates produced by this method may be analyzed by ICP or GFAA.

2.0 Summary of Method

2.1 A representative sample of 50ml is digested in 3mls concentrated nitric acid for 20 minutes using microwave heating with a suitable laboratory microwave units.

2.2 The sample and acid are placed in a Teflon microwave vessel. The vessel is heated in the microwave. The cooled sample is filtered and diluted to volume.

3.0 Interferences

Each matrix type can contain different interferences. Spiked samples and standard reference materials should be processed with the each sample batch.

Many samples that contains organics such as TCLP extracts will result in high vessel pressure, which have the potential to vent. A smaller sample size may be used.

4.0 Sample Preservation and Holding Time

4.1 Samples should be taken in pre-cleaned plastic containers.

4.2 Samples must be kept cold after sampling and until digestion. 4 ± 2°C.

4.3 Samples should be acidified to a pH <2 with HNO_3.

4.4 Samples must be digested and analyzed within 6 months of sampling.

5.0 Health and Safety

All safety procedures as outlined in the Chemserve Chemical Hygiene Plan will be followed. At a minimum, safety glasses, gloves and lab coats will be worn when handling chemicals, regents and client samples.

Read manufactures' instructions for health and safety concerns regarding the operation and maintenance of the microwave units.

6.0 Materials

6.1 Microwave unit with corrosion resistant cavity and ventilation. Corrosion proof electronics, rotating turntable (minimum speed 3 rpm).

6.2 Digestion vessels – 120ml capacity PFA or TFM fluorocarbon, capable of withstanding 110 ±10psi and capable of controlled venting.

6.3 Analytical balance – capable of weighing to 0.01g.

6.4 Centrifuge tube – plastic graduated

6.5 DI water – trace metal free

6.6 Nitric Acid – concentrated

6.7 Filter Paper

6.8 Filter funnels – glass or polypropylene

7.0 Procedure

7.1 Calibration of Microwave Equipment
If the microwave unit uses temperature feedback control capable of replicating the performance specifications of the method, then the calibration may be omitted. See method for calibration procedures.

7.2 All digestion vessels and volumetric glassware must be carefully acid washed and rinsed with DI water.

7.2.1 Rinse vessels with 1:1 nitric acid.

7.2.2 Rinse thoroughly with DI water.

7.2.3 Store dry in a clean environment.

Sample Digestion

7.3 Label vessels, digestate tubes and carousel tray positions. Fill out prep log with carousel position #s.

7.4 Add 50mls of the well mixed sample to the digestion vessel; less volume can be used for samples containing high concentrations of orgaincs, dilute to 50mls.

7.5 Add 3ml ±0.1ml of concentrated nitric acid (perform this step in a fume hood)

NOTE: Toxic Nitrogen oxide fumes may be generated. Prepare samples under a hood.
When digesting samples that contain volatiles or easily oxidized organic compounds, if a vigorous reaction occurs, allow too cool before capping.

7.6 Add the 1.0ml of 50ppm spike solutions (final concentration = 1.0ppm) to the MS/MSD and blank spike.

7.7 Label one centrifuge tube for each sample to be digested. Label tubes for any prep blanks, duplicates and matrix spikes.

7.8 Log the lot number of the digestion round in the log book. The first 1-2 digits is the month, the third and fourth digits are the day and the next two are the year. The Final digit is the digestion round for the day. For example, on January 6th 2000, the second carousel of the day would be 010600-2.

7.9 Select the vessel that has the largest and most reactive sample to be the temperature/ pressure monitor vessel. Install pressure relief valves, bubble side up, and caps on remaining vessels. Place collection container into turntable with slot facing monitor vessel. Install vent tubes into remaining vessels and collection container. * Be sure that the transparent valve on the monitor vessel is in the open position. *

7.10 Check that the handle on the two way valve is in the horizontal position (open) with the arrow pointing toward the pressure relief valve. Place an empty 250ml beaker in the microwave cavity. Place the open end of the pressure sensing tube in the beaker and push the plunger on the syringe to force DI water through the tubing until no air bubbles are coming out. Remove the beaker and discard the DI. Return the two way valve to the neutral position (closed)

7.11 Place the turntable onto the drive adapter in the microwave cavity. Insert the open end of the pressure sensing tubing through the ferrule nut of the pressure port of the monitor control vessel. Tighten the ferrule nut.

7.12 Turn the slotted retaining ring to the open position. Insert the pressure sensing tube through the vertical standoff on the collection container. Route the slotted standoff along the pressure sensing tube. Then turn the locking ring to secure both.

7.13 With instrument door open, press **F4** to rotate the turntable. Allow the turntable to rotate 2 or 3 times to ensure that the turntable rotates freely.

7.14 Close the microwave door and recall the program to be used.

7.17Program Recalling Procedure:

7.17.1 From the *Main Menu*, press **F3** (Recall Method/Data). Press **F1** to Recall Stored Method.

7.17.2 Press ↓ (the down arrow key) to scroll through the program list until the desired program is highlighted. Press **Enter**, the *Load* screen will appear.

7.17.3 **Load Program** will be highlighted.

7.17.4 Press **Enter** or **F1** to load the selected program. The *Operation* screen will appear.

7.17.5 Press **F3** (REVIEW) to modify the program % power to reflect the number of 50ml samples Use arrow keys to scroll to each power stage and enter new setting. Be sure to press **Enter** or arrow key to accept last entry. When finished press **F3** to end and return to the *Operation* screen.

7.17.6 Press **F4** to begin the procedure using the recalled program. The *Run* screen will appear. The *Run* screen displays all pertinent information:

- A moving wave to indicate microwaves are being produced.
- The programmed power.
- The filename.
- The current and programmed pressure.
- The current and programmed time.

The current and programmed temperature is also displayed with the temperature option installed. Press **F1** to abort the procedure. Press **F3** to display an x-y coordinate graph of time versus pressure as it is happening. If the temperature option is installed and enabled, a graph can be displayed of time vs. temperature.

7.17.7 When the procedure utilizing the recalled method is completed, the *Run* screen will remain on the display. The wave will be a flat line. Press **F1**. The display will read **F1-Main Menu/F3-Graph To Printer**. Press **F1** to return to the *Main Menu.*

7.18 Irradiate the sample for 15 minutes, following a temperature ramping procedure. 10 minutes at 50%, 5 minutes at 90-100%, when digesting 12 vessels. Cut power by appropriate amount when digesting less than 12 vessels (6 vessels only use ½ the power, etc.).

7.19 Allow vessels to cool for 5 minutes before removing from the unit.

7.20 Tighten the transparent valve clockwise to the closed position and remove the pressure/temperature sensing lines. Remove the turntable from the system.

7.15 Carefully uncap and vent each vessel in a hood.

7.16 For samples requiring silver add 2.0mls of NH_4OH to each sample and spike sample. Return to microwave and heat for 2-3 minutes.

7.17 Allow vessel to cool.

7.18 Carefully uncap and vent each vessel in a hood.

7.21 Filter or decant sample into a digestate tube.

7.22 Dilute digestate to 50.0 ml.

8.0 Quality Control

8.1 For each batch of samples processed a method blank should be carried throughout the entire digestion procedure.

8.2 Spike duplicate samples should be processed on a routine basis and when a new matrix is being analyzed. Spiked duplicates are used to determine precision and bias.

8.3 IF TCLP samples are being digested as part of the batch, a TCLP MS/MSD and tumbled duplicate and tumbled blank must be prepared in addition to the normal batch QC.

TEST **DETERMINATION OF METALS AND TRACE ELEMENTS WATER BY ICP**

METHOD: **EPA 200.7**

REFERENCE: **EPA method 200.7 1982**

1.0 SCOPE AND APPLICATION

1.0 This method is applicable to the analysis of drinking water, water and wastewater.

1.1 With the exception of silver, this method is approved for the determination of some metals in drinking water without digestion if the sample has been properly preserved and has a turbidity of <1 NTU at the time of analysis. However some primary drinking water metals may need digestion prior to analysis in order to meet drinking water criteria.

1.2 This method can be used to determine dissolved analytes in aqueous samples after filtration and acid preservation. Dissolved solids should be <0.2% (W/V).

1.3 For the determination of total analytes in aqueous matrix with particles or suspended solids a digestion is required prior to analysis.

1.4 When determining silica or boron in aqueous samples, only plastic or quartz lab ware should be used. Borosilicate glassware will introduce contamination.

2.0 SUMMARY METHOD

2.0 An aliquot of well mixed, homogenous aqueous sample is measured for sample processing. For total recoverable analysis of a sample containing undissolved material, analytes are treated with nitric acid and digested on a hotplate. After cooling, the sample is brought up to volume and filtered if necessary before analysis. For the determination of dissolved analytes in a filtered aqueous sample, the sample is acidified with nitric acid, diluted and mixed before analysis.

2.1 Samples are nebulized and the resulting aerosol is transported to the plasma torch. Element specific emissions spectra are produced by a radio frequency inductively coupled plasma. A background correction technique is required to compensate for variable background noise. Other interferences must also be considered and addressed.

3.0 INTERFERENCES

3.0 Memory interference results when analytes in a previous sample contribute to the signal measured in a new sample (especially Sodium, Potassium and Silica). Memory effects can result from sample deposition on the uptake tubing to the nebulizer or from sample build up in the plasma torch and spray chamber. This can be minimized by flushing the system with a rinse blank between samples. The required rinse time between samples and standards is 60 seconds until a laboratory standard is set.

3.1 Chemical interference includes molecular compound formation, ionization effects and solute vaporization effects. Chemical interference are highly dependent on matrix type and the specific element.

4.0 SAMPLE COLLECITON, PRESERVATION AND HOLDING TIME

4.1 The pH of all aqueous samples must be tested immediately prior to aliquoting for processing or direct analysis. The sample must be preserved with nitric acid to a pH of <2. Samples for the analysis of dissolved metals must be filtered through a 0.45 μm glass fiber filter prior to acidification.

4.2 Sample containers must be plastic

4.2 Samples must be kept at 4°C ± 2

4.4 Holding time is 6 months for all metals except Mercury, which is 28 days.

5.0 HEALTH AND SAFETY

All safety procedures as outlined in the Chemserve Chemical Hygiene plan will be followed. At a minimum, a lab coat, safety glasses and gloves will be worn when handling client samples, chemicals and reagents.
Concentrated Nitric Acid is extremely irritating to skin and mucous membranes. Use under a hood.
The inductively coupled plasma should only be viewed with proper eye protection from the ultra violet emissions.

Digestates are disposed of in the ICP waste stream after 30 days.

6.0 REAGENTS AND STANDARDS

6.1 Nitric Acid – concentrated

6.2 Reagent water – DI water

6.3 50 and 100ml Volumetric Flasks

6.4 Standard Stock Solutions – Ultra High purity (99.9-99.999% pure) standards can be purchased pre-made or made from individual analytes. Concentration for each element is100ppm

6.4.1 From the 100ppm Commercial Stock standard solution
Acidify Standards with nitric acid to a pH <2 before bring up to final volume.

mls of Stock	Final Volume mls	Final conc mg/L
0.0	100	0
25.0	50	50.0
10.0	100	10.0
5.0	100	5.0
2.5	100	2.5

mls of 10.0mg/L	Final Volume mls	Final Conc. mg/L
10.0	100	1.00

mls of 1.00mg/L	Final Volume mls	Final Conc. mg/L
10.0	100	0.100

mls of 0.100mg/L	Final Volume mls	Final Conc. mg/L
10.0	100	0.010

6.5 Instrument Performance Check solution (IPC /CCV)– verify instrument performance during analysis. Prepare the IPC from the same Standard Stock solutions used to calibrate the instrument. All analytes should be at a concentration of 2.5 mg/l.

6.6 Quality Control Sample (ICV)– Analysis of a QCS is required for initial and periodic verification of calibration standards or stock standard solutions in order to verify instrument performance. The QCS must be obtained from a source different from the standard stock solution and prepared in the same acid mixture as the calibration standard. The concentration of the analytes in the QCS solution should be >1.0 mg/l. All compounds are at 2.00 mg/L. A fresh solution should be prepared quarterly or more frequently if needed.

6.7 Spectral Interference Check solutions (ICS) - When interelement corrections are applied, SIC solutions are needed containing concentrations of the interference elements at levels that will provide an adequate test of the correction factor.

6.7.1 For interferences from iron and aluminum, only those correction factors (positive or negative) when multiplied by 100 to calculate apparent analyte concentrations that exceed the determined analyte IDL or fall below the lower 3-sigma control limit of the calibration blank need be tested on a daily basis.

6.7.2 If the correction routine is operating properly, the determined apparent analyte(s) concentration from analysis of each interference solution should fall within a specific concentration range bracketing the calibration blank. This concentration range is calculated by multiplying the concentration of the interfering element by the value of the correction factor being tested and dividing by 10. If after subtraction of the calibration blank the apparent analyte concentration is outside (above or below) this range, a change in the correction factor of more than 10% should be suspected. The cause of the change should be determined and corrected and the correction factor should be updated.

6.7.3 If the correction factors tested on a daily basis are found to be within the 10% criteria for 5 consecutive days, the required verification frequency of those factors may be extended to a weekly basis. Also if the samples analyzed are finished drinking water daily verification is not required. However, all interelement correction factors must be verified annually and updated as necessary.

7.0 QUALITY CONTROL

7.1 Initial demonstration of performance

7.1.1 The Linear range of the instrument, method detection limit, IDL and the analysis of quality control samples must be analyzed prior to the analysis of samples.

7.1.2 The Linear range of the instrument must be verified every 6 months. However at this time we operate well below the Linear Range of any element.

7.2 Quality control sample (QCS) – On a quarterly basis and after the preparation of stock or calibration standard solutions 3 QCS's must be analyzed. The mean concentration of the 3 analysis must be within ±5% of the stated values.

7.3 Method Detection Limit - MDL's must be established using DI water fortified at a concentration of 2-3 times the estimated IDL. A minimum of 7 replicates must be analyzed.

7.4 Method blank – a reagent blank, DI water acidified with nitric acid must be analyzed with each batch or every 20 samples of the same matrix. The blank results cannot exceed the MDL or contamination must be suspected. If the method blank has values of greater that 10% of the sample value or 2.2 times greater than the MDL, the samples must re-digested and analyzed.

7.5 Blank Spike (BS) (laboratory Fortified blank) - The laboratory must analyze at least one blank spike with each batch of samples. The recovery must be with 85-115%. Laboratory generated limits should be developed when sufficient points have been generated.

7.6 ICV/CCV – The laboratory must analyze the IPC solution and a calibration blank immediately following the daily calibration and after every 10 samples. The Initial IPC run must verify that

the instrument is within ±5 % of the calibration. Subsequent analysis of the IPC solution should within ±10% of the calibration. If the calibration is not verified by these analysis, the IPC solution should be reanalyzed. If the second analysis of the IPC solution confirms the calibration is out, the instrument must be re-calibrated and all samples following the last acceptable IPC check must be reanalyzed.

7.7 Matrix Spike sample – (laboratory fortified matrix) The lab must spike a known amount of analyte to a minimum of 5% of routine samples (1 in 20 samples of the same matrix). The % recovery should be between 80-120%. Recovery calculations are not required if the concentration of the spike is less than 30% of the sample background concentration. If the Matrix spike is outside control limits and the blank spike is in control for that analyte a matrix effect can be suspected. Analysis by standard addition should be considered for the sample. If the sample concentration is >4x the spike amount, the % recovery is not calculated.

7.8 Matrix Spike duplicate sample – The lab must analyze a minimum of 5% of routine samples as duplicates(1 in 20 samples of the same matrix). The % RPD between the sample and duplicate should be <20%. If the sample concentration is < 10 time the MDL the %RPD is not calculated.

7.9 Standard of Method Additions(MSA)

7.9.1 Standards are added at one or more levels to portions of a prepared sample. This technique compensates for enhancement or depression of an analyte signal by a matrix. It will not correct for contamination, interelement interferences or baseline shifts. The recovery of the elements should be within 85-115% of the known value. The analyte addition should produce a minimum level of 20 times and a maximum of 100 times the method detection limit. If the analyte addition is <20% of the sample analyte concentration, then the dilution test should be performed. If the recovery of the analyte is not within the specified limits, a matrix effect should be suspected and the associated data should be flagged as such.

7.9.2 Dilution test:- If the analyte concentration is sufficiently high, (>50x the detection limit but <90% of the linear limit) an analysis of a 1+4 dilution should agree within ±10% of the original determination. If not, a chemical or physical interference should be suspected and the associated data flagged.

8.0 Calibration and Analysis

8.1 Prior to daily calibration of the instrument inspect the sample introduction system including the nebulizer, torch, injector tube and uptake tubing for salt deposits, dirt, and debris that would restrict solution flow and affect instrument performance. Clean the system as needed. For more specific guidelines on instrument maintenance and operation refer to the Spectro ICP operating manual.

8.2 The instrument must be warmed up a minimum of 20-30 minutes before use.

8.3 For initial and daily operation calibrate the instrument according to the manufacturer's recommendations using mixed calibration standard solutions and the calibration blank. Use the average value of replicate integration periods of the signal to be correlated to the analyte concentration.

8.3.1 The initial calibration sequence consists of 7 standards and a blank. The concentrations of the standards are 0, 0.010, 0.100, 1.00, 2.5, 5.0, 10 and 50 ppm. The correlation coefficient of the calibration curve must be ≥0.996. The correlation coefficient for sodium and potassium can be ≥0.995.

8.3.2 Following the calibration of the instrument an Independent calibration verification (IV7-19) sample is analyzed. The concentration for all elements is 2ppm.

8.3.3 Manual Regression must be performed on all elements to ensure acceptable curve fit. After this has been completed a PQL check must be analyzed, if it is not the lowest curve point. This is to verify the detection limits are attainable based on the regression of the calibration through zero.

8.3.4 Interference Control Sample containing selected elements is analyzed to show there is no interference at selected wavelengths. This data must be kept on file.

8.4 A daily calibration verification and a blank is analyzed before client samples are run. This is the highest standard in the calibration curve. A continuing calibration verification is analyzed every 10 client samples. The concentration is 2.5ppm. The CCV that is analyzed at the end of the run must be at a different concentration than the beginning CCV.

8.5 Samples should be analyzed in the same operational manner that the calibration is analyzed, with rinse blanks in between each sample, spike blank, matrix spike and check solution.

8.6 Analysis sequence should be as follows. Blank, Calibration standards, ICV, Calibration Blank, IPC (CCV),method blank, LCS, Sample 1, Matrix spike, Matrix Spike Duplicate, 9 Client Samples, CCV, CCB.

8.7 Samples greater than the highest calibration standard must be diluted with acidified DI water and re-analyzed. Also, for the interelement interference correction factor to remain valid during the analysis the concentration must not exceed its LDR. If the interferent LDR is exceeded, sample dilution and reanalysis is required.

8.8 Method of Standard Additions. The simplest version of this technique is the single addition method. Two Identical aliquots of the sample solution is taken. To one aliquot a small volume of standard is added, to the second aliquot an equal volume of acid blank is added. The sample concentration is calculated by the following.

Sample Conc. =

$$\frac{s_2 \times v_1 \times C}{(s_1 - s_2) \times v_2}$$

Where : C = Concentration of the standard solution (mg/L)
S_1 = Signal for fortified aliquot
S_2 = Signal for unfortified aliquot
V_1 = Volume of standard addition (L)
V_2 = Volume of the sample aliquot (L) used for MSA

For more than one fortified portion of the prepared sample, linear regression analysis can be applied.

8.9 For data to be accepted it must be within ≤10% of the highest calibration standard and the % RSD between the three injections must be ≤20%. Sample data should be reported in mg/L for aqueous.

8.10 For dissolved aqueous analytes, report the data directly from the instrument, sample dilutions should be taken into account though. Do not report analyte concentrations below the MDL.

8.11 For total recoverable analytes, multiply solution concentrations by the dilution factor 0.5, when 100ml aliquot is used to produce the 50ml final solution. If a different dilution volume is used other than the 100ml adjust the factor accordingly. Also account for any additional dilution of the sample aliquot.

$$\text{Instrument results} \times \frac{\text{F.V.} \times \text{DF}}{\text{IV}}$$

8.12 For solid samples use the following calculation. Report data up to 3 significant figures as mg/kg dry weight.

Sample conc. (mg/kg) =

$$\frac{C \times V \times D}{W}$$

Where: C = Concentration in extract (mg/L)
V = Volume of extract (L)
D = Dilution factor (undiluted = 1)
W = Dry weight (in kg) of sample aliquot (g x 0.001 = kg)

8.13 Report results that are less than the detection limit or negative values as < the method detection limit.

TABLE 1

ELEMENT	WAVELENGTH (nm)	UPDATED IDL (ug/L)
Aluminum Al	308.215	30
Antimony Sb	206.833	100
Arsenic As	193.696	50
Barium Ba	455.403	5
Beryllium Be	313.042	1
Boron B	249.678 x 2	10
Cadmium Cd	226.505	2.3
Calcium Ca	317.933	10
Chromium Cr	267.716	4.7
Cobalt Co	228.616	4.7
Copper Cu	324.754	3.6
Iron Fe	259.940	4.1
Lead Pb	220.353	30
Lithium Li	670.784	2.8
Magnesium Mg	279.079	10
Manganese Mn	257.610	1
Mercury Hg	194.227 x 2	17
Molybdenum Mo	202.030	5.3
Nickel Ni	231.604 x 2	10
Phosphorous P	213.618	51
Potassium K	766.491	1000
Selenium Se	196.026	50
Silica SiO_2	251.611	17
Silver Ag	328.068	5
Sodium Na	588.995	1000
Strontium Sr	407.771	1
Thallium Tl	190.864	100
Tin Sn	189.980 x 2	17
Titanium Ti	334.941	5.0
Vanadium Vn	292.402	5.0
Zinc Zn	213.856 x 2	5

TEST: **DETERMINATION OF INORGANIC ANIONS BY ION CHROMATOGRAPHY**

METHOD: **300.0**

REFERENCE: **EPA 300.0 rev. 2.1 Aug. 1993**

1.0 SCOPE AND APPLICATION

1.1 This method is applicable to the following inorganic anions in drinking water, wastewater and solids(after extraction), Bromide, Chloride, Fluoride, Nitrate, Nitrite, o-Phosphate and Sulfate.

2.0 SUMMARY OF METHOD

2.1 A small volume of sample, 25.0ul is introduced into an ion chromatograph. The anions of interest are separated and measured, using a system comprised of a guard column, analytical column suppressor device and a conductivity detector.

2.2 An extraction procedure must be performed before solids can be analyzed.

3.0 INTERFERENCES

3.1 Interferences can be caused by substances with retention times that are similar and or overlap those of the anion of interest. Large amounts of anions can cause interference with peak resolution of another anion. Sample dilution can be used to solve most interference problems associated with retention times.

3.2 The water dip that elutes near fluoride can be corrected with manual integration if needed.

3.3 Samples that contain particles larger than 0.45 microns and reagent solutions that contain particles larger than 0.20 microns should be filtered to prevent damage to the columns and flow systems. The auto sampler caps have filters in them. For caps that do not contain filters, filter the sample using a nylon syringe filter.

3.4 The acetate anion elutes early during the chromatographic run. This method is not recommended for leachates of solid samples when acetic acid is the extraction fluid.

4.0 HEALTH AND SAFETY

4.1 All safety procedures as outlined in the Chemserve Chemical Hygiene plan will be followed. At a minimum, a lab coat, safety glasses and gloves will be worn when handling client samples, chemicals and reagents.

5.0 EQUIPMENT AND SUPPLIES

5.1 Dionex Ion Chromatograph with all necessary equipment and detectors

5.2 AG-14 guard column and AS14 Analytical column. Both columns are 4mm.

5.3 4mm ASRS Conductivity Suppressor.

5.4 Autosampler with poly vials and caps

5.5 Reagent water - Deionized, free of anions of interest. Water should contain particles no larger than 0.20 microns.

5.6 Eluent solution – 0.5M Na_2CO_3/0.5M $NaHCO_3$

Dissolve 26.49g of Na_2CO_3 in 400 ml of DI water. Dilute to a final volume of 500ml = 0.5M.
Dissolve 21.00g of $NaHCO_3$ in 400 ml of DI water. Dilute to a final volume of 500ml = 0.5M.
Add 14ml of Na_2CO_3 solution and 4mls $NaHCO_3$ solution to 2L volumetric. This is the final eluent solution. Background conductivity should be around 18.0-20.0µs

5.7 Ion Chromatography grade standards for calibration standards – commercially prepared 100ppm Ion standard

5.7.1 Prepare calibration standards using the 100ppm stock solution - See Analysis cover sheet for directions.

Standards should be prepared in dedicated glassware (or disposable) due to possible Cl, NO_3 and SO_4 interferences in laboratory glassware.

The upper linear range for all compounds is 5.0ppm, but 10.0 ppm can be used if needed as long as QC supports it.

6.0 SAMPLE PRESERVATION AND HOLDING TIME

6.1 Samples should be collected in pre-cleaned plastic or glass bottles.

6.2

Analyte	Preservation	Holding Time
Nitrate-N	None	48 hours
Nitrite-N	None	48 hours
Nitrate-n/Nitrite	H_2SO_4	28 days
Bromide	None	28 days
Chloride	None	28 days
Fluoride	None	28 days
O-Phosphate	None	48 hours
Sulfate	None	28 days

6.3 All samples should be stored at 4°C.

7.0 PROCEDURES

7.1 Instrument set-up and conditions

7.1.1 Turn on the Helium gas, the pressure should be approximately 10 psi.

7.1.2 Fill the reservoir with prepared eluent (5.6) and de-gas for at least 15 minutes.

7.1.3 Make sure the waste bottle is not full and is connected to the instrument.

7.1.4 Turn on the large white button on the left-hand side of the instrument.

7.1.5 Let the instrument warm up for 30-40 minutes or wait until background conductivity is stable.

7.1.6 In the Browser Menu choose the directory "DX120_Anions". Then choose "MyPanels". Then choose the ":DX120.PAN" file.
Hit the "Connect" button to connect to the instrument.
Turn on the Eluent Pressure, pump and SRS through the software.

7.1.7 Check the instrument conductivity. The conductivity should be 18-19.5 μs.

7.2 Set up auto sampler run with calibration standards and QC using auto sampler manual.

7.3 Check retention times before calibrating by running a mid-curve standard. Re-enter the retention times into the method if they have changed. Reload the method (run/file). Go into My Methods/Anions and choose the "Calibration Tab"

7.4 To run the method (if re-calibrating). Set up the sequence using the "New Sequence Wizard" Enter the standards to run and flag them as standards within the software sequence. Run batch using "Batch-Start".

7.5 Once all the standards are run check the cal plot of each of the anions by going into main menu/cal plot/file name. This will bring up all the plots of the anions run. The correlation coefficient should be ≥0.995 for each anion. The minimum amount of points in the calibration curve is three.

7.6 Once the calibration curve is established the QC and samples may be loaded on the auto sampler. Fill each auto sampler tube with approximately 5mls of sample or diluted sample. Place in the auto sampler tray. Enter sample queue and dilution amounts into the computer.

7.7 If you are analyzing samples without running a new calibration curve, analyze a blank and a continuing calibration verification (CCV) sample to verify the curve is valid prior to the analysis of samples. The CCV must be with 10% of the true value. A CCV of a different concentration must be analyzed at the end of the run.

7.8 The auto sampler will inject 25.0ul of the 5.0ml vial into the instrument. If the response for any ion exceeds the working range (5.00ppm) of the system, dilute the sample with an appropriate amount of reagent water and reanalyze.

7.9 Solid Samples

7.9.1 Weigh out 1.00 g of sample.

7.9.2 Add 50mls of DI water. Stir for 5 minutes then allow too settle.

7.9.3 Filter through a 0.45 um filter, use a vacuum if necessary.

7.9.4 Analyze filtrate.

7.10 Document all runs (samples and QC) in the daily run log. Calculate the % recovery and % RPD for all QC samples.

7.11 Instrument Shut down

7.11.1 When complete: method/file/stop/method. This will automatically shut the instrument down. It can be done manually by placing into the local mode and shutting off the 3 buttons in an upward sequence. The instrument will also "safety shutdown" if left idle for 3 hours.

8.0 QUALITY CONTROL

8.1 Initial demonstration of performance.

8.1.1 MDL – MDL's must be established for all anions. This is done by analyzing 7 replicates of DI water fortified at a concentration 2-3 times the estimated instrument detection limit. MDL's should be updated every 6 months or when there is a change in the instrument response.

8.1.2 Calibration Range – the calibration range of each anion must be determined prior to analysis of samples and verified every 6 months or when changes occur in instrument response. If the Daily CCV exceeds 10% recovery the calibration must be reestablished.

8.2 Ongoing Performance

8.2.1 A method blank (MB) must be analyzed every 10 samples. The blank results must not exceed the reporting limit.

8.2.2 Blank Spike – (BS. DIMS) A blank spike (laboratory fortified DI Water) must be analyzed every 10 samples. Calculate accuracy as percent recovery. If the blank spike is outside 90-110% recovery the problem must be corrected before analysis can continue. See Analysis Cover Sheet for spiking directions.

8.2.3 Calibration Check – (ICV and CCV continuing calibration check) a calibration check must be analyzed before sample analysis can begin, after every ten samples and at the end of the sample run. The end CCV must be at a different concentration. % Recovery must be within 10% of the True value. If the CCV is out of control sample analysis must stop until the cause of the problem is corrected. All samples analyzed after an out of control CCV must be reanalyzed.

8.2.4 Matrix Spike, Matrix spike duplicate - shall be analyzed every 10-20 samples. % Recovery must be 90-110%. % RPD must be≤25. Matrix spikes shall be picked randomly unless specified by the client. After a column or other major instrument consumable material has been changed the % Recovery should be within 80-120% until 20 points have been established. Verify status of instrument in the maintenance logbook.

8.2.5 Rerun the highest standard after calibrating to verify the upper linear calibration (LCR) of the instrument.

8.2.6 The ICV can also be used as the QCS sample.

8.3 Report results in mg/L

8.4 Report NO_2 and NO_3 as N and PO_4 as P.

9.0 REPORT AND FILE RECREATION

9.1 To print out or review data, go to sequence file, double click of appropriate sample and print form the file menu.

9.2 MANUAL INTEGRATION

Open file of interest in "The Sequence". From the file toolbar choose "Set baselines manually" then choose "Show start & stop markers". Using the mouse, drag the start marker to where you want the peak measurement to begin. Do the same for the stop marker. This should only have to be done to correct any inappropriate fluoride integration due to the water dip being so close. Fixing this integration will adjust so negative peak detection is not added to the result.

10.0 WASTE DISPOSAL

10.1 Return unused sample to the appropriate location in walkin refrigerator.

10.2 Neutralize waste from waste jug and dispose down the drain.

10.3 Dump the remainder of samples in the tubes into the disposal bucket, neutralize and dispose.

11.0 DEFINITIONS

11.1 Preparation batch = samples that are prepared together with the same process and personnel using the same lot(s) of reagents. A batch is 1-20 samples of the same matrix prepared within 24 hours.

11.2 Method Blank = MB DI water that goes through the entire preparation

11.3 Blank Spike = BS(DIMS) Laboratory control sample, Laboratory fortified sample. DI water spiked with a known amount of the analyte of interest.

11.4 Quality Control Sample – (QCS)- Used to verify the calibration curve. This is also an ICV or a CCV.

Anions By Ion Chromatography

Date:_____ Method:_____

Analyst:_____ Instrument:_____

Calibration Standard Lot #:_____

Independent Standard Lot #:_____

Last Calibration Date:_____ Eluent ID#: _____

Calibration Standard Preparation: *Cal Standard Curve ID:* CAL-_____

From the 100mg/l multi anion calibration stock make the following standards:

Amount of 100mg/l	Final Volume	Concentration
0.05 mls	50ml	0.100 mg/l
0.250 mls	50ml	0.500 mg/l
0.500 mls	50ml	1.00 mg/l
1.00 mls	50ml	2.00 mg/l
2.50 mls	50ml	5.00 mg/l
5.00 mls	50ml	10.0 mg/l

Independent Check Standard Preparation: *ICV Check ID:* ICV-_____

From the 100mg/l independent standard stock make the following standards:

Amount of 100mg/l	Final Volume	Concentration
2.50mls	50ml	5.00 mg/l

Matrix Spikes are spiked using 50% of sample and 50% of the 10.0 mg/l calibration standard for a final concentration of 5.00 mg/l. (Acceptance limits 90%-110%) DI Spikes are 5.00 mg/l prepared the same as the 5.00 mg/l calibration standard. (Acceptance limits 90%-110%) QC frequency is 10%.

Comments: _____

_____

_____. Reviewed By: _____

QA/Manager: 12/11/03
Dept. Manager: 12/11/03

TITLE **DETERMINATION OF TOTAL PHOSPHOROUS**

METHOD: **EPA 365.2**

REFERENCES: **EPA 365.2**

1.0 SCOPE AND APPLICATION

This method covers the determination of specified forms of phosphorous in drinking, surface and saline waters, domestic and industrial wastes.
Phosphorous analysis rely on two procedural steps, 1) conversion of phosphorous into dissolved ortho phosphate and 2) colorimetric determination of dissolved O-Phosphate.

2.0 SUMMARY OF METHOD

2.1 Ammonium Molybdate and antimony potassium tartrate react in an acid medium with dilute solutions of phosphorous to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue colored complex by ascorbic acid. The color is proportional to the amount of phosphorous present.

2.2 Only O-Phosphate forms a blue color in this test. Poly phosphates and organic phosphates must be converted to O-Phosphate by a persulfate digestion.

2.3 If dissolved O-phosphate or dissolved total Phosphorous are needed, filter the sample before proceeding with section 7.0.

3.0 INTERFERENCES

This method requires dedicated glassware to limit phosphate contamination from dishwashing liquids. All glassware must be washed with 1:1 HCL and rinsed with DI water.

4.0 HEALTH AND SAFETY

Follow all Health and Safety procedures as outlined in the Chemserve Chemical Hygiene Plan. At a minimum a lab coat, safety glasses and gloves will be worn when handling client samples, chemicals or reagents.

5.0 PRESERVATION AND HOLDING TIME

5.1 Sample in glass or plastic bottle.

5.2 Sample is preserved with 2mls of H_2SO_4 per liter.

5.3 Sample should be stored at 4°C and analyzed within 28 days of sampling. If sample has not been preserved it must be analyzed within 48 hours.

6.0 EQUIPMENT AND REAGENTS

6.1 Spectrophotometer – 650nm

6.2 Acid washed glassware.

6.3 Sulfuric Acid solution 5N – Dilute 69.9mL concentrated sulfuric acid with DI water to 500mL.

6.4 Antimony potassium tartrate solution – Weigh 1.3715g $K(SbO)C_4H_4O_6 \bullet 1/2H_2O$, dissolve in 400mL DI water, dilute to 500mL with DI water. Store at 4°C in an amber bottle.

6.5 Ammonium molybdate solution – Dissolve 20g $(NH_4)_6Mo_7O_{24} \bullet 4H_2O$ in 500mL DI water. Store at 4°C in a plastic bottle.

6.6 Ascorbic Acid 0.1M – Dissolve 1.76g of ascorbic Acid in 100mL DI water. Store at 4°C, this solution is stable for 1 week.

6.7 Combined reagent – **ALL REAGENTS MUST BE AT ROOM TEMPERATURE BEFORE MIXING**. Mix the above reagents in the following proportions for 100ml of the mixed reagent. 50mL 5N H_2SO_4 (6.3), 5mL of Antimony potassium tartrate (6.4), 15ml of ammonium molybdate (6.5) and 30ml of ascorbic acid (6.6), Mix after the addition of each reagent. If turbidity forms, shake and let stand until turbidity disappears before proceeding. This solution must be made fresh each day. This reagent is stable for 4 hours.

6.8 Sulfuric Acid 11N – slowly add 310ml of concentrated sulfuric acid to 600ml of DI water, when cool dilute to 1.0 liter.

6.9 Ammonium persulfate.

6.10 Stock Phosphorous solutions – Commercially prepared . If not purchased prepared then dissolve 0.2197g potassium dihydrogen phosphate (KH_3PO_4) (which has been oven dried at 105°C) in 1000mL DI water. 1.0mL = 0.05mgP

6.10.1 Standard Phosphorous solution – Dissolve 10mL stock solution (6.10) into 1.0 liter DI water. 1.0mL = 0.5ugP

6.11 Sodium Hydroxide 6N – Dissolve 240g NaOH into 600mL DI water. Cool and dilute to 1.0L.

6.12 Sulfuric Acid 1N – add 27.96mls of conc sulfuric acid into DI water. Bring volume up to 1.0 liter.

7.0 PROCEDURE

7.1 Phosphorous

7.1.1 Add 1.0mL H_2SO_4 (11N) to a 50mL sample in a 125mL flask.

7.1.2 Add 0.40g (2 level scoops) of ammonium persulfate.

7.1.3 Boil gently on a hot plate until a final volume of approx. 10mls has been reached. Do not allow sample to go to dryness.

7.1.4 Cool and dilute to 30mL with DI water. Add 1 drop of phenolphthalein indicator. Add 6N NAOH dropwise until pink color appears. Neutralize to a pH of 7.0 by adding 1N H_2SO_4 dropwise until pink color disappears.

7.1.5 Dilute to 50mls with DI water and proceed to section (7.3.2).

7.2 Solid samples.

7.2.1 Add 1.0g of well mixed sample to a 125ml beaker. Add 50 ml of DI water.

7.2.2 Add 1.0mls of H_2SO_4 (11N) to a 50mL sample.

7.2.3 Add 0.40g (2 level scoops) of ammonium persulfate.

7.2.4 Boil gently on a hot plate until a final volume of approx. 10mls has been reached. Do not allow sample to go to dryness.

7.2.5 Filter sample prior to adjusting the pH as in sec. 7.1.4.

7.2.6 Proceed to section 7.3.2.

7.3 Orthophosphate

7.3.1 Adjust pH of sample (25mL) to 7.0 ±0.2 units using 1N NaOH or 1N H_2SO_4.

7.3.2 To 25mls of digestate add 4.0mL of combined reagent (6.7) to sample, mix thoroughly.

7.3.3 After a minimum of 10 minutes but no longer than 30 minutes measure the color absorbance of each sample at 650nm.

7.3.4 Obtain concentration of sample directly from prepared calibration curve. Results are reported as P, mg/L.

7.3.5 If sample results are above the linear range of the instrument, it must be re-digested at a dilution. A dilution cannot be made on the colored sample. If a dilution is anticipated, digest the sample at 2 different dilutions or dilute from the remaining 25mls that were not colored.

8.0 QUALITY CONTROL

8.1 Analyze a blank sample with every batch. A batch is designated as 20 samples or the amount of samples analyzed in 24 hours, which ever is less.

8.2 Analyze a blank spike sample every batch. See logbook for preparation instructions. See logbook cover for limits.

8.3 Analyze a matrix spike/matrix spike duplicate sample every 20 samples. See logbook for preparation instructions and limits.

8.4 Analyze a known sample certified by an outside agency every 20 samples. Sample must fall within limits specified by the agency for that parameter.

8.5 Analyze a blank and the calibration curve before any samples. The correlation coefficient must be ≥0.995. The curve must contain one point at the detection limit with the rest of the points covering the linear range the method. See the logbook for standard solution dilutions. Analyze a known check sample to verify the curve is valid.

8.6 If a calibration curve is not analyzed then a continuing calibration verification (CCV) sample must be analyzed to verify the curve is valid. The results should be within 80-120% recovery. A CCV must also be analyzed at the end of the sample sequence. This CCV must be a different concentration than the beginning CCV. See logbook for preparation instructions.

9.0 SAMPLE DISPOSAL

9.1 Return sample container to its correct shelf in the walkin refrigerator.

9.2 Place sample aliquot that has been analyzed into the disposal buckets in the double sink. This bucket will be neutralized and rinsed down the drain.

Rev. Date: 03/04/04
GN056.5
QA/Manager: 3/4/04
Dept. Manager: 3/4/04

TITLE **DETERMINATION OF SPECIFIC CONDUCTANCE**

METHOD: **EPA 120.1**
SM 2510

REFERENCES: **SM 18TH, 2510, EPA 120.1 Rev.1982**

P&A Analyst **Paul Fyfe, Kevin Dentel, Tim Dodge**

1.0 SCOPE AND APPLICATION

This method is applicable to drinking, surface and saline water, domestic and industrial wastes and acid rain.

2.0 SUMMARY OF METHOD

Conductance is the reciprocal of resistance, and is expressed in mhos or umhos. When the cell constant is known and applied, the measured conductance is converted to the specific conductance or conductivity.

Conductance is the ability for an aqueous solution to carry an electrical current. This depends on the presence of ions, their total concentration, mobility, valence, relative concentrations and on the temperature at the time of measurement. Solutions of inorganic acids, bases, and salts are good conductors of electricity. Molecules of organic compounds that do not dissociate in aqueous solutions are poor conductors. Conductivity is determined by resistance and is measured in ohms or megohms. The resistance of a conductor is inversely proportional to its cross sectional area and directly proportional to its length. Magnitude of resistance measured in a sample depends upon the characteristics of the conductivity cell used.

3.0 INTERFERENCES

3.1 Protect Conductivity Cell from damage by storing in protective foam sleeve.

4.0 HEALTH AND SAFETY

Follow all Health and Safety procedures as outlined in the Chemserve Chemical Hygiene Plan. At a minimum a lab coat, safety glasses and gloves will be worn when handling client samples, chemicals or reagents.

Dispose of samples in the neutralization vessel.

5.0 PRESERVATION AND HOLDING TIME

5.1 Sample in a plastic or glass container.

5.2 No preservation is required.

5.3 Sample should be stored at 4°C and analyze and no later than 28 days after sampling.

6.0 EQUIPMENT AND REAGENTS

6.1 Conductivity meter – Fisher digital conductivity meter with automatic temperature compensation. Serial # 97056 B46

6.2 Conductivity cell – cell constant 0.1/cm platinized electrode.

6.3 Beakers.- 50ml Pyrex beakers or equivalent

6.4 DI water – conductivity <1umhos/cm

6.5 Standard potassium chloride solution – (KCL 0.01N) ACS Grade anhydrous KCL Fisher # P217 Dissolve 0.7456g of anhydrous KCl in DI water. Dilute to 1000mls.

6.6 Alpha-Trol - Alpha –Trol Inc #1026 Current lot # recorded in Chemical Receipt Logbook and analysis logbook.

6.7 Known – VHG Minerals QCpMIN 2x20 prepared per Mfq. Instructions

7.0 PROCEDURE

7.1 Determine the Cell constant Monthly using EPA 120.1

7.1.1 Rinse the cell with 3 portions of 0.01M KCl

7.1.2 Measure the conductance of the 0.01M KCl Standard

7.1.3 To determine the cell constant, divide the conductivity from the chart by the actual measured amount.

Conductivity 0.01 M KCl °C	micomhos/cm
21	1305
22	1332
23	1359
24	1386
25	1413
26	1441
27	1468
28	1496

7.1.4 Record Cell constant in analysis logbook.

7.2 Let standard and samples equilibrate to room temperature.

7.3 Calibrate meter daily with Alpha-Trol. Set exact true value using set screw in back of meter.

7.4 Check the calibration with a Known sample.

7.5 Rinse cell at least twice with DI water between samples.

7.6 Rinse the cell with several portions of the sample.

7.7 Add sample to a beaker, use enough to cover the cell. DO NOT TOUCH BOTTOM OF CONTAINER WITH CELL unless probe has a cell protection sleeve.

7.8 Set x factor knob to 20 and unit knob to MHO. If conductivity is high increase X factor knob until conductivity is in range. (multiplication factors are as follows).

Range	Multiplication Factor
20	1
200	1
2000	1
20,000	1000
200,000	1000

7.9 Multiply the cell constant by the conductance reading, and the multiplication factor, report results as specific conductance in umhos/cm.

8.0 QUALITY CONTROL

8.1 Analyze a blank sample with every batch. A batch is designated as 20 samples or the amount of samples analyzed in 24 hours, which ever is less.

8.2 Analyze a sample in duplicate every batch. A batch is 20 samples or the amount of samples analyzed in 24 hours, whichever is less. Calculate the %RPD and record in logbook.

$$\%RPD = \frac{|A-B|}{(A+B)/2} \times 100$$

8.3 Analyze a known sample certified by an outside agency. Sample must fall within limits specified by the agency for that parameter.

8.4 Calculate the cell constant <u>monthly.</u>

8.5 Conductivity Meter is serviced and calibrated annually by Q.C. Services.

Rev. Date: 7/08/03
GN019.4
QA/Manager: 7/10/03
Dept. Manager: 7/10/03

TITLE **DETERMINATION OF TOTAL DISSOLVED SOLIDS**

METHOD: **2540C SM18TH**
EPA 160.1

REFERENCES: **SM 18TH, 2540C, EPA 160.1 Rev.1971**

1.0 SCOPE AND APPLICATION

This method is applicable to drinking water, surface water and saline water, domestic and Industrial wastes.

2.0 SUMMARY OF METHOD

A portion of thoroughly mixed sample is filtered under vacuum through a filter. The particles that are dissolved in the sample pass through the filter. The filtrate is dried at a constant temperature of 180°C and weighed. Those solids capable of passing through a glass fiber filter are considered dissolved solids.

3.0 INTERFERENCES

Highly mineralized water containing significant concentrations of calcium, magnesium, chloride and sulfate may be hydroscopic and will require prolonged drying, desiccation and rapid weighing.

4.0 HEALTH AND SAFETY

Follow all Health and Safety procedures as outlined in the Chemserve Chemical Hygiene Plan. At a minimum a lab coat, safety glasses and gloves will be worn when handling client samples, chemicals or reagents.

5.0 PRESERVATION AND HOLDING TIME

5.1 Sample in a plastic or glass 250ml container.

5.2 No preservation is required.

5.3 Sample should be stored at 4°C and analyzed ASAP and no later than 7 days after sampling.

6.0 EQUIPMENT AND REAGENTS

6.1 Drying oven – capable of maintaining 180°C.

6.2 Analytical Balance
6.3 Glass fiber filter discs
6.4 Filtration Apparatus
6.5 Membrane filtration funnel
6.6 DI water.
6.7 ERA known sample or equivalent –
6.8 100ml evaporating dishes – porcelain.
6.9 Drying oven capable of maintaining 103°C.

7.0 PROCEDURE

7.1 Place evaporating dish in drying oven and dry at 180°C for 1 hour.

7.2 Place in a dessicator until cool.

7.3 Weigh and record weight.

7.4 Repeat (7.2-7.4). If the weight difference between the two weights is less than 0.5 mg the evaporating dish can be used. If not repeat the drying cycle again.

7.5 Assemble the filtration unit placing filter on unit wrinkle side up. Turn on vacuum.

7.6 Rinse filter with 3, 10ml portions of DI water. Remove all traces of water by continuing to apply the vacuum after the water has passed through. Discard washings.

7.7 Shake sample vigorously and measure 75ml using a graduated cylinder.

7.8 Pour sample into the filter apparatus.

7.9 If the filter clogs or does not filter in a reasonable amount of time, a smaller amount of sample can be used.

7.10 Wash the graduated cylinder and filter unit with 10ml DI water. Repeat this 3 times, allowing the water to drain completely between washings.

7.11 Allow filtration unit to run for three minutes after all traces of water are gone.

7.12 Carefully transfer sample to evaporating dish.

7.13 Dry sample at 103°C. until almost dry. Transfer sample to 180°C. oven. Sample is evaporated in cooler oven initially to prevent boiling and spattering of sample.

7.14 Dry dish for at least 2 hours after dryness at 180°C. Record beginning and end Oven temperature in the log book.

7.15 Samples containing high concentrations of bicarbonate require prolonged drying to insure bicarbonate is converted to carbonate. Too much residue in dish will crust over and entrap water.

7.16 Cool in a dessicator.

7.17 Weigh to the nearest 0.1mg.

7.18 Repeat the drying and cooling cycle.

7.19 Reweigh, if a constant weight is not achieved (less than 0.5mg difference) continue the drying cycle.

7.20 Calculation

$$\text{TDS in mg/L} = \frac{A-B \times 1000}{C}$$

A = Weight of dried residue and dish mg.
B = Weight of dish in mg.
C= ml of sample filtered.

NO BLANK SUBTRACTING

8.0 QUALITY CONTROL

8.1 Analyze a blank sample with every batch. A batch is designated as 20 samples or the amount of samples filtered in 24 hours, which ever is less.

8.2 Analyze a sample in duplicate every 20 samples. Calculate the %RPD. See logbook cover for limits.

8.3 Analyze a known sample certified by an outside agency (6.8). Sample must fall within limits specified by the agency for that parameter.

QA/Manager: 8/20/03
Dept. Manager: 8/20/03

TITLE **DETERMINATION OF NITROGEN-TOTAL KJEDAHL**

METHOD: **4500-NH_{ORG} SM18TH**
EPA 351.3

REFERENCES: **SM 18TH, 4500-NH_{ORG} EPA 351.3**

1.0 SCOPE AND APPLICATION

This distillation method covers the determination of total Kjeldahl nitrogen, in drinking water, surface and saline waters, domestic and industrial water. The process converts nitrogen components of biological origin to ammonia. After distillation the TKN can be determined colorimetrically (range 0.25-3.0 mg/L).

2.0 SUMMARY OF METHOD

The sample is heated in the presence of concentrated sulfuric acid, K_2SO_4 and $HgSO_4$ and evaporated until SO_3 fumes are obtained and the sample is colorless. The residue is cooled and diluted and is treated and made alkaline with hydroxide thiosulfate solution. The ammonia is distilled and determined after distillation by Nesslerization. TKN is defined as the sum of free ammonia and organic nitrogen that are converted to ammonium sulfate.

3.0 INTERFERENCES

3.1 High nitrate concentration (10X>TKN level) will result in low TKN values. The reaction between nitrate and ammonia can be prevented by the use of an anion exchange resin to remove nitrate before TKN analysis.

4.0 HEALTH AND SAFETY

Follow all Health and Safety procedures as outlined in the Chemserve Chemical Hygiene Plan. At a minimum a lab coat, safety glasses and gloves will be worn when handling client samples, chemicals or reagents.

All waste generated from this analysis must be disposed in the Mercury waste stream.

5.0 PRESERVATION AND HOLDING TIME

5.1 Sample in a plastic 100ml container.

5.2 Sample is preserved with 2ml of 1:1sulfuric acid per liter of sample.

5.3 Sample should be stored at 4°C and analyzed within 28 days of sampling.

6.0 EQUIPMENT AND REAGENTS

6.1 Spectrophotometer at 425nm.

6.2 DI water – ammonia free

6.3 Labconco multi-distillation apparatus.

6.4 Sodium Hydroxide/Sodium Thiosulfate solution – Sodium Hydroxide12N Add 480g and 3.5g $Na_2S_2O_3 \bullet 5H_2O$ in 1000mls DI water. Use caution, this reaction generates heat. This step should be done in a hood in a cold water bath.

6N Sodium Hydroxide/Sodium Thiosulfate for cleaning tubes. Add 240g sodium hydroxide and 3.5g $Na_2S_2O_3 \bullet 5H_2O$ in 1000mls of DI water. Use caution, this reaction generates heat. This step should be done in a hood in a cold water bath.

6.5 Mercuric Sulfate solution – 4g red mercuric oxide diluted in 50mls of 6N H_2SO_4.

6.6 Digestion reagent – 134g K_2SO_4 diluted in 650mls DI water, slowly add 200mls concentrated H_2SO_4. Stir and add 25mls of Mercuric sulfate solution. Bring up to 1.0 liter of DI water.

6.7 2% Boric Acid – 20g H_3BO_3 diluted to 1000mls.

6.8 HACH Nessler reagent – purchased pre-made. Stable until it becomes discolored.

6.9 Standards - Add 3.819g anhydrous NH_4Cl to one liter of water. (1mL = 1mg NH_3-N). See log book for directions and concentrations of working standards.

6.10 Boiling chips – pretreated with NaOH.

7.0 PROCEDURE

Digestion

7.1 Digestion block tube cleaning

7.1.1 Steam clean w/ $NaOH/Na_2S_2O_3$ between samples –6N

7.1.1 Add 10mls of solution and boiling chip into each tube.

7.1.2 Heat to 100°C for 30 min.

7.1.3 Raise heat to 150°C for 1-2 hours until liquid turns a light straw color.

7.1.4 When tubes are cool enough to handle but liquid has not solidified fill tube halfway with DI water to dilute.

7.1.5 Rinse 3 times with DI water. This is done by filling each tube completely with DI water and draining. Store tubes upside down when complete.

7.2 Measure 20mls of blank, blank spike, samples, matrix spike and sample duplicate into digestion block vessels.

7.2.1 If the sample is a solid, use between 0.5 and 1.0g and 20mls of DI water.

7.3 Spike the blank spike and matrix spike sample according to the instructions in the logbook.

7.4 Add boiling chip.

7.5 Add 5mls of TKN digestion reagent (6.7) and mix.

7.6 Set Heating block to 160° until volume is about 5-10mls.

7.7 Increase temperature to 360°C and heat for 4.0 hours .

7.8 Digest sample until large volumes of white fumes are observed. Continue to digest samples until the liquid becomes clear or straw colored. Turn off heat.

7.9 Allow to cool, add about 5mls of DI water to the tube. Mix well and cover. Samples can stand covered if needed.

7.10 If the sample is high in organic content, it may require a more rigorous digestion. Allow the digestate to cool and add 2.5mls of concentrated H_2SO_4. Add 5.0 additional mls of Sodium hydroxide-sodium thiosulfate solution at the distillation step to allow for proper pH adjustment.

Distillation

7.11 Cleaning Distillation flasks.
7.11.1 Clean each flask between use.

7.11.2 Add 50mls of DI water and 50mls of 12NNaoH/sodium thiosulfate to each flask.

7.11.3 Heat until 60-80mls have been distilled.

7.11.4 Rinse with DI water three times.

7.12 For use with 800ml Kjedahl flask macro-distillation units.

7.13 Place a 50ml receiver flask containing 5.0mls of 2% boric acid under the condenser. Tube must be submerged under the liquid.

7.14 Add entire TKN digestate to the distillation flask. Rinse the digestion tube with DI water and add to the flask.

7.15 Add a few boiling chips and approx. 100mls of DI water.

7.16 Slowly add 10 mls of 12N sodium hydroxide-sodium thiosulfate solution to the flask so that an alkaline layer is formed on the bottom of the flask. DO NOT MIX!

7.17 Set heat to high.

7.18 A black precipitate (HgS) will form as boiling, when the precipitate forms the pH is above 11.

7.19 Distill until at least 30mls of sample have been collected. Turn off heat. Transfer to 50ml volumetric flask, bring to volume if needed with DI water.

Analysis - Colorimetric

7.20 Zero the spectrophotometer on a reagent blank at 425nm.

7.21 Analyze a CCV to validate the calibration curve, if the result is not within 80-120% of the true value a new calibration must be performed. A CCV of a different concentration than the beginning CCV must be analyzed at the end of the run.

7.22 To calibrate the instrument, prepare a set of standards ranging from 0.25 mg/L-3.0 mg/L. See bench log for dilutions and concentrations. The correlation coefficient must be ≥0.995, for the curve to be valid.

7.23 Measure 25 mls of distillate into a Nessler tube.

7.24 Add 0.5mL Nessler reagent to each 25ml distillate. Swirl to mix. Allow 15 minutes for color development.

7.25 Read the absorbance of samples and record in the log book. If the result is above the linear range of the instrument dilute and reanalyze.

7.26 The result is Ammonia-N. The TKN concentration should be greater or equal to the ammonia concentration.

7.27 TKN and ammonia are analyzed separately if TON (total organic nitrogen) is needed. Subtract ammonia from the TKN value.

8.0 QUALITY CONTROL

8.1 Process and analyze a blank sample and a blank spike with every batch. A batch is designated as 20 samples or the amount of samples digested and or distilled in 24 hours, which ever is less.

8.2 Analyze a Matrix spike and a duplicate sample every 20 samples. See logbook for recovery limits.

8.3 Analyze a known sample certified by an outside agency. Sample must fall within limits specified by the agency for that parameter.

Rev. Date: 11/05/02
GN013.3
QA/Manager: 11/7/02
Dept. Manager: 11/7/02

TITLE **DETERMINATION OF TOTAL SUSPENDED SOLIDS**

METHOD: **2540D SM18TH**
EPA 160.2

REFERENCES: **SM 18TH, 2540D, EPA 160.2 Rev.1971**

1.0 SCOPE AND APPLICATION

This method is applicable to drinking water, surface water and saline water, domestic and Industrial wastes.

2.0 SUMMARY OF METHOD

A portion of thoroughly mixed sample is filtered under suction through a filter. The particles that are suspended in the sample are trapped on the filter. The filter is dried at a constant temperature of 103°C and weighed.

3.0 INTERFERENCES

Non representative particles such as sticks, leaves, fish and organic matter will falsely raise the results. Omit these particles from the procedure.
Samples high in dissolved solids will give a false high reading if the filter is not thoroughly rinsed.

4.0 HEALTH AND SAFETY

Follow all Health and Safety procedures as outlined in the Chemserve Chemical Hygiene Plan. At a minimum a lab coat, safety glasses and gloves will be worn when handling client samples, chemicals or reagents.

5.0 PRESERVATION AND HOLDING TIME

5.1 Sample in a plastic or glass 250ml container.

5.2 No preservation is required.

5.3 Sample should be stored at 4°C and analyzed ASAP and no later than 7 days after sampling.

6.0 EQUIPMENT AND REAGENTS

6.1 Aluminum weighing pans – or equivalent.

6.2 Drying oven – capable of maintaining 103-105°C.

6.3 Analytical Balance
6.4 Glass fiber filter discs
6.5 Filtration Apparatus
6.6 Membrane filtration funnel
6.7 DI water.
6.8 ERA known sample or equivalent

7.0 PROCEDURE

7.1 Pre-rinse filter with 3 20ml portions of DI water following steps (7.8-7.9).

7.2 Place filter on drying tray and dry at 103-105°C for 1 hour.

7.3 Place in a dessicator until cool.

7.4 Weigh

7.5 Repeat (7.2-7.4) If the weight difference between the two weights is less than 0.5 mg the filter can be used. If not repeat the drying cycle again.

7.6 Step (7.1-7.5) can be omitted if it shown the filters contain no contaminants.

7.7 Weigh the filter immediately before use. Record in the logbook.

7.8 Assemble the filtration unit, placing filter on unit wrinkle side up. Turn on suction.

7.9 Wet the filter with a small amount of DI water.

7.10 Shake sample vigorously and measure 100ml using a graduated cylinder.

7.11 Pour sample into the filter apparatus.

7.12 If the filter clogs or does not filter in a reasonable amount of time a smaller amount of sample can be used.

7.13 Wash the graduated cylinder and filter unit with 10ml DI water. Repeat this 3 times, allowing the water to drain completely between washings.

7.14 Allow filtration unit to run for three minutes after all traces of water are gone.

7.15 Remove filter disc using forceps, place on a drying tray.

7.16 Dry filter for at least 1 hour at 103-105°C. Record beginning and end Oven temperature in the log book.

7.17 Cool in a dessicator.

7.18 Weigh to the nearest 0.1mg.

7.19 Repeat the drying and cooling cycle.

7.20 Reweigh, if a constant weight is not achieved (less than 0.5mg difference) continue the drying cycle.

7.21 Calculation

$$\text{TSS in mg/L} = \frac{A-B \times 1000}{C}$$

A = Weight of filter and sample residue in mg.
B = Weight of filter in mg.
C= ml of sample filtered.

NO BLANK SUBTRACTING

8.0 QUALITY CONTROL

8.1 Analyze a blank sample with every batch. A batch is designated as 20 samples or the amount of samples filtered in 24 hours, which ever is less.

8.2 Analyze a sample in duplicate every 20 samples. The duplicate results should agree within 5% of the average.

8.3 Analyze a known sample certified by an outside agency (6.8) every 20 samples. Sample must fall within limits specified by the agency for that parameter.

Rev. Date: 06/13/03
GN016-4
QA Manager: 6/19/03
Dept. Manager: 6/19/03

TEST: **DETERMINATION OF TURBIDITY**

METHOD: **180.1**

REFERENCE: **EPA 180.1 rev. 1978**
Sm 2130B 18th ed.

1.0 SCOPE AND APPLICATION

This method is applicable to drinking water, surface and saline waters. The range of analysis is 0.5-40 NTU. Over 40NTU the sample must be diluted.

2.0 SUMMARY OF METHOD

This method is based on a comparison of the intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference sample. The higher the intensity of scattered light the higher the turbidity.

3.0 INTERFERENCES

3.1 The presence of floating debris and coarse sediments which settle out rapidly will give low readings. Finely divided air bubbles will also give a low reading.

4.0 HEALTH AND SAFETY

4.1 All safety procedures as outlined in the Chemserve Chemical Hygiene plan will be followed. At a minimum, a lab coat, safety glasses and gloves will be worn when handling client samples, chemicals and reagents.

Dispose of samples in the neutralization bucket.

5.0 SAMPLE PRESERVATION AND HOLDING TIME

5.1 Samples should be collected in pre-cleaned plastic or glass bottles. No preservative is required.

5.2 All samples should be stored at 4°C.

5.3 Sample should be analyzed ASAP. Analyze within 48 hours.

6.0 EQUIPMENT AND SUPPLIES

6.1 Nephelometer – Hach model Ratio/XR Turbidmeter or equivalent

6.2 Clear colorless glass sample tubes – tubes must be kept scrupulously clean, both inside and outside. Discard when scratched or etched.
Glass tubes must not be handled where the light path strikes.

6.3 Reagent water - deionized, turbidity free.

6.4 Hach –sealed standard kit or equivalent

6.5 Hach - liquid calibration standards or equivalent.

7.0 PROCEDURES

7.1 Instrument must be warmed up at least ½ hour before starting analysis. It is advisable not to turn the instrument off during the day.

7.2 Calibrate the instrument monthly with Sealed Standards. The standards should cover the range of interest. Analyze a 0, 18.0, and 180 NTU. Report calibration date on each notebook page.

7.3 Allow standards and samples to come to room temperature before use.

7.4 Calibrate the instrument following the attached calibration procedures. Follow steps A-D.

7.5 Check the calibration with an independent Formazin standard or a sealed standard at 18NTU. Add 0.45mls of the 4000NTU standard to 100mls of DI water. This will give you an 18 NTU standard. The results should be ±25% of the true value.

7.6 Daily analyze the sealed standards (CCV) to verify the calibration.

0-20	18.0 NTU std.
20>	180 NTU std.
0	0 NTU

7.6.1 Place the sealed standard in the instrument in its indexed position.

7.7 Analyze a blank sample daily. The blank result must be <0.50 NTU. Record in the logbook.

7.8 Shake the sample thoroughly.

7.9 Pour sample into the turbidimeter tube.
Do not touch glass other than the top of the tube

7.10 Wipe down the outside of the tube with a clean dry chemwipe.

7.11 If the sample contains air bubbles, tap gently with a pencil eraser.

7.12 Place tube in the instrument with the index marking in the same spot every time.

7.13 Read the results from the instrument scale. Record results in log book.

7.14 If the sample is greater than 40NTU, it must be diluted.

7.15 Dilute sample with one or more volumes of DI water until turbidity
Sample Calculation for dilutions
Results in NTU = $\frac{A \times B}{}$
A = instrument reading in NTU
B = Dilution Factor

8.0 QUALITY CONTROL

8.10 Calibrate with sealed standards monthly and check with an independent Formazin solution or a sealed standard.

8.11 Blank water must be Turbidity free.

8.12 Analyze a duplicate once per batch. A batch is 20 samples or what can be analyzed in 24 hours, whichever is smaller. See logbook cover for %RPD limits.

8.13 Analyze a CCV daily results must be ±25% true value as per instrument specifications.

APPENDIX K

RI Analytical Laboratory Materials

AUG 2 - 2005

NEW HAMPSHIRE ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM

R.I. Analytical Laboratories, Inc. 41 Illinois Ave., Warwick, RI 02888 (401) 737-8500
Analyte List Number: 253705-B Date of Issue: July 22, 2005 Expiration Date: April 19, 2006

GRANTS SECONDARY ACCREDITATION TO THE ABOVE MENTIONED LABORATORY FOR THE FOLLOWING ANALYSES:

NON-POTABLE WATER METALS

Aluminum, Total	EPA 200.7
Antimony, Total	EPA 200.7
Arsenic, Total	EPA 200.7
Barium, Total	EPA 200.7
Beryllium, Total	EPA 200.7
Boron, Total	EPA 200.7
Cadmium, Total	EPA 200.7
Calcium, Total	EPA 200.7
Chromium, Total	EPA 200.7
Cobalt, Total	EPA 200.7
Copper, Total	EPA 200.7
Iron, Total	EPA 200.7
Lead, Total	EPA 200.7
Magnesium, Total	EPA 200.7
Manganese, Total	EPA 200.7
Molybdenum, Total	EPA 200.7
Nickel, Total	EPA 200.7
Potassium, Total	EPA 200.7
Selenium, Total	EPA 200.7
Silica, Dissolved	EPA 200.7
Silver, Total	EPA 200.7
Sodium, Total	EPA 200.7
Thallium, Total	EPA 200.7
Tin, Total	EPA 200.7
Titanium, Total	EPA 200.7
Vanadium, Total	EPA 200.7
Zinc, Total	EPA 200.7
Chromium VI	SM 18-19 3500-Cr D
Mercury, Total	EPA 245.1

NON-POTABLE WATER INORGANIC CONTAMINANTS

Acidity	EPA 305.1
Alkalinity	EPA 310.1
Biochemical Oxygen Demand	EPA 405.1
Biochemical Oxygen Demand	SM 18-20 5210B
Chemical Oxygen Demand	EPA 410.4
Chloride	SM 18-20 4500-Cl B
Color	EPA 110.1
Cyanide, Total	EPA 335.2
Fluoride, Total	EPA 340.1

NON-POTABLE WATER INORGANIC CONTAMINANTS

Hardness, Total	EPA 200.7
Hydrogen Ion (pH)	EPA 150.1
Kjeldahl Nitrogen, Total	EPA 351.3
Nitrate (as N)	EPA 353.3
Nitrite (as N)	EPA 353.3
Oil & Grease Total Recoverable	EPA 1664A
Organic Carbon, Total	EPA 415.1
Orthophosphate (as P)	EPA 365.2
Phenols	EPA 420.1
Phosphorus, Total	EPA 365.2
Solids, Total Dissolved	EPA 160.1
Solids, Total Suspended	EPA 160.2
Solids, Total	EPA 160.3
Specific Conductance	EPA 120.1
Sulfate (as SO4)	EPA 375.4
Sulfide (as S)	EPA 376.1
Surfactant (MBAS)	EPA 425.1
Temperature	EPA 170.1

PCBs IN NON-POTABLE WATER

PCB-1016	EPA 608
PCB-1221	EPA 608
PCB-1232	EPA 608
PCB-1242	EPA 608
PCB-1248	EPA 608
PCB-1254	EPA 608
PCB-1260	EPA 608

PESTICIDES IN NON-POTABLE WATER

4,4'-DDD	EPA 608
4,4'-DDT	EPA 608
Aldrin	EPA 608
alpha-BHC	EPA 608
beta-BHC	EPA 608
Chlordane Total	EPA 608
delta-BHC	EPA 608
Endosulfan I	EPA 608
Endosulfan sulfate	EPA 608
Endrin aldehyde	EPA 608
Endrin	EPA 608

This analyte list supercedes all previously issued analyte lists.
Method accreditation does not imply acceptance for NHDES compliance testing.
Laboratory is required to use EPA approved methods where required by regulation.

Bill Hall
Program Manager

AUG 2 - 2005

NEW HAMPSHIRE ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM

R.I. Analytical Laboratories, Inc. 41 Illinois Ave., Warwick, RI 02888 (401) 737-8500
Analyte List Number: 253705-B Date of Issue: July 22, 2005 Expiration Date: April 19, 2006

GRANTS SECONDARY ACCREDITATION TO THE ABOVE MENTIONED LABORATORY FOR THE FOLLOWING ANALYSES:

PESTICIDES IN NON-POTABLE WATER

Heptachlor epoxide	EPA 608
Heptachlor	EPA 608
Lindane	EPA 608
Toxaphene	EPA 608

VOLATILE ORGANICS IN NON-POTABLE WATER

1,1,1-Trichloroethane	EPA 624
1,1,2,2-Tetrachloroethane	EPA 624
1,1,2-Trichloroethane	EPA 624
1,1-Dichloroethane	EPA 624
1,1-Dichloroethene	EPA 624
1,2-Dichlorobenzene	EPA 624
1,2-Dichloroethane	EPA 624
1,2-Dichloropropane	EPA 624
1,3-Dichlorobenzene	EPA 624
1,4-Dichlorobenzene	EPA 624
2-Chloroethylvinyl ether	EPA 624
Acrolein (Propenal)	EPA 624
Acrylonitrile	EPA 624
Benzene	EPA 624
Bromodichloromethane	EPA 624
Bromoform	EPA 624
Bromomethane	EPA 624
Carbon tetrachloride	EPA 624
Chlorobenzene	EPA 624
Chloroethane	EPA 624
Chloroform	EPA 624
Chloromethane	EPA 624
cis-1,3-Dichloropropene	EPA 624
Dibromochloromethane	EPA 624
Dichlorodifluoromethane	EPA 624
Ethyl benzene	EPA 624
Methylene chloride	EPA 624
Tetrachloroethene	EPA 624
Toluene	EPA 624
Total Xylenes	EPA 624
trans-1,2-Dichloroethene	EPA 624
trans-1,3-Dichloropropene	EPA 624
Trichloroethene	EPA 624
Trichlorofluoromethane	EPA 624
Vinyl chloride	EPA 624

NON-POTABLE WATER SEMIVOLATILE ORGANICS

1,2,4-Trichlorobenzene	EPA 625
2,4-Dichlorophenol	EPA 625
2,4-Dimethylphenol	EPA 625
2,4-Dinitrophenol	EPA 625
2,4-Dinitrotoluene	EPA 625
2,6-Dinitrotoluene	EPA 625
2-Chloronaphthalene	EPA 625
2-Chlorophenol	EPA 625
2-Methyl-4,6-dinitrophenol	EPA 625
2-Nitrophenol	EPA 625
3,3' -Dichlorobenzidine	EPA 625
4-Bromophenylphenyl ether	EPA 625
4-Chlorophenylphenyl ether	EPA 625
4-Nitrophenol	EPA 625
Acenaphthene	EPA 625
Acenaphthylene	EPA 625
Anthracene	EPA 625
Benzo(a)anthracene	EPA 625
Benzo(a)pyrene	EPA 625
Benzo(b)fluoranthene	EPA 625
Benzo(ghi)perylene	EPA 625
Benzo(k)fluoranthene	EPA 625
Benzyl butyl phthalate	EPA 625
Benzidine	EPA 625
Bis (2-chloroisopropyl) ether	EPA 625
Bis(2-chloroethoxy)methane	EPA 625
Bis(2-chloroethyl)ether	EPA 625
Chrysene	EPA 625
Dibenzo(a,h)anthracene	EPA 625
Diethyl phthalate	EPA 625
Dimethyl phthalate	EPA 625
Di-n-butyl phthalate	EPA 625
Di-n-octyl phthalate	EPA 625
Fluoranthene	EPA 625
Fluorene	EPA 625
Hexachlorobenzene	EPA 625
Hexachlorobutadiene	EPA 625
Hexachlorocyclopentadiene	EPA 625
Hexachloroethane	EPA 625
Indeno(1,2,3-cd)pyrene	EPA 625
Isophorone	EPA 625
Naphthalene	EPA 625
Nitrobenzene	EPA 625
N-Nitrosodimethylamine	EPA 625

This analyte list supercedes all previously issued analyte lists.

Bill Hall
Program Manager

Method accreditation does not imply acceptance for NHDES compliance testing.
Laboratory is required to use EPA approved methods where required by regulation.

AUG 2 - 2005

NEW HAMPSHIRE ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM

R.I. Analytical Laboratories, Inc. 41 Illinois Ave., Warwick, RI 02888 (401) 737-8500
Analyte List Number: 253705-B Date of Issue: July 22, 2005 Expiration Date: April 19, 2006

GRANTS SECONDARY ACCREDITATION TO THE ABOVE MENTIONED LABORATORY FOR THE FOLLOWING ANALYSES:

NON-POTABLE WATER SEMIVOLATILE ORGANICS

N-Nitrosodi-n-propylamine	EPA 625
N-Nitrosodiphenylamine	EPA 625
Pentachlorophenol	EPA 625
Phenanthrene	EPA 625
Phenol	EPA 625
Pyrene	EPA 625

This analyte list supercedes all previously issued analyte lists.
Method accreditation does not imply acceptance for NHDES compliance testing.
Laboratory is required to use EPA approved methods where required by regulation.

Bill Hall
Program Manager

R.I. Analytical

Specialists in Environmental Services

QUALITY MANUAL
FOR
RI Analytical Laboratories, Inc.
REVISION # 003

EFFECTIVE DATE
November 14, 2002

Prepared by:
RI Analytical Laboratories, Inc.
41 Illinois Ave.
Warwick, RI 02888
401-737-8500

November 14, 2002

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Figure 2-1. Organization chart

Table 2-1. RI Analytical Laboratories, Inc. Capabilities

1) POLICY STATEMENT

This Quality Manual summarizes the policies and operational procedures associated with RI Analytical Laboratories, Inc (RIAL) in Warwick, Rhode Island. Protocols for sample handling and storage, chain-of-custody, and laboratory analyses, data reduction, corrective action, and reporting are described. All policies and procedures have been structured in accordance with the NELAC standards and applicable EPA requirements, regulations, guidance, and technical standards. This manual has been prepared in accordance with the guidance documents listed in Section 15. Specific details on these policies and procedures are contained in SOPs and related documents. This Quality Manual, SOPs, and related documentation describe the quality system for RI Analytical Laboratories, Inc. (RIAL).

The Quality Manual provides personnel and customers of RI Analytical Laboratories, Inc. with a description of company policy for maintaining an effective quality assurance system, planned and developed in conjunction with other management planning functions.

RI Analytical Laboratories, Inc. performs chemical analyses for inorganic and organic constituents in water and soil. RI Analytical Laboratories, Inc. goal is to produce data that is scientifically valid, defensible, and of known and documented quality in accordance with standards developed by the National Environmental Laboratory Accreditation Conference (NELAC) and any applicable state or EPA regulations or requirements. A Certification Statement (see Appendix A) has been recorded to this effect.

RI Analytical Laboratories, Inc. analyzes Proficiency Test samples at least two times per year from a NIST-approved PT provider for the analytes established by EPA for water samples. RI Analytical Laboratories, Inc. analyzes Proficiency Test samples at least two times per year from a ISO 9001 registered PT provider for other analytes and matrices. The specific analytes and matrices analyzed are based on the current scope of the laboratory services.

The technical and service requirements of all requests to provide analyses are thoroughly evaluated before commitments are made to accept the work. This includes a review of facilities and instrumentation, staffing, and any special QC or reporting requirements to ensure that analyses can be performed within the expected schedule. All measurements are made using published reference methods or methods developed by RI Analytical Laboratories, Inc. Competence with all methods is demonstrated according to the procedure described in Appendix B and an Initial Demonstration of Capability prior to use.

RI Analytical Laboratories, Inc. has developed a proactive program for prevention and detection of improper, unethical or illegal actions. Components of this program include:);

electronic data audits and post-analysis data review by the QC Coordinator; a program to improve employee vigilance and co-monitoring; and SOPs identifying appropriate and inappropriate laboratory and instrument operation practices.

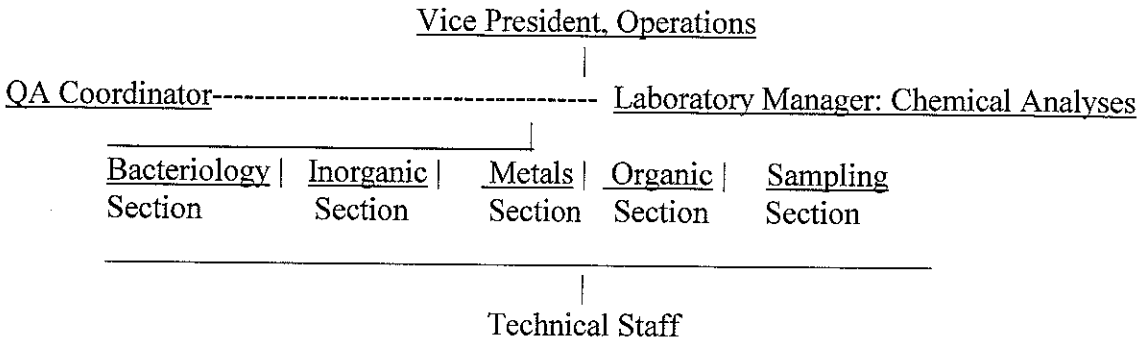
2.0 ORGANIZATION AND RESPONSIBILITIES

2.1 Organization Chart / Job Descriptions

An organization chart for RI Analytical is shown in Figure 2-1. This chart includes all individuals discussed below. Job descriptions for all individuals are maintained in the Human Resources department.

Figure 2-1: ORGANIZATIONAL CHART

RI Analytical Laboratories, Inc.



JOB DESCRIPTION

VICE PRESIDENT OF OPERATIONS

The Vice President of Operations is responsible for the following activities and responsibilities as a minimum:

- Define the minimum level of experience and skills for new hires and existing positions within the company
- Supervise all department managers, customer service, and sales personnel
- Oversee all analytical documentation and Certificates of Analysis
- Oversee all necessary training, both in-house and outside training
- Assure that all technical staff have demonstrated proficiency in the activities for which they are responsible
- Make sure that all sample acceptance criteria are verified and followed
- Make sure that all samples are logged into the LIMS system correctly and properly labeled and stored
- Responsible for Management System Review
- Make sure that the lab has the capabilities to perform new work
- Make sure Corrective Actions are instituted and completed
- Make sure that the mission statement of RI Analytical Laboratories, Inc. particularly the ethics statement is followed

JOB DESCRIPTION Q.C. COORDINATOR

The Q.C. Coordinator reports to the Vice President of Operations but has no immediate or direct day-to-day responsibilities for the generation of analytical data. Some of the responsibilities of the Q.C. Coordinator, though not all inclusive, are:

- Conduct internal audits to assure valid analytical data
- Monitor Corrective Actions to completion
- Notify lab management of any deficiencies in the QC/QA systems of RI Analytical Laboratories, Inc.
- Monitor the acquisition of Performance Testing (PT) samples at least 2 times per year.
- Assist in the training of the technical staff in QA/QC reporting requirements

JOB DESCRIPTION-LAB MANAGER

Listed below are some of the responsibilities of the Lab Manager. These responsibilities are the minimum expectations, however additional responsibilities may become part of the job description as delegated by the Vice President, or President of RI Analytical.

- Monitor Q.C. and Q. A. performance
- Monitor data validation on a day to day basis
- Make sure that the lab has the necessary resources, i.e., lab space, personnel and equipment to perform the work of the laboratory
- Make sure that appropriate chemicals, standards, and equipment is ordered to perform the work of the laboratory
- Supervise the technical staff of the laboratory
- Train the technical staff in the skills required to perform the technical aspects of the analyses

JOB DESCRIPTION- Section Supervisors

Listed below are some of the responsibilities of the Section Supervisor. These responsibilities are the minimum expectations, however additional responsibilities may become part of the job description as delegated by the Lab Manager, Vice President, or President of RI Analytical.

- Monitor Q.C. and Q. A. performance
- Monitor data validation on a day to day basis
- Make sure that the lab has the necessary resources, i.e., lab space, personnel and equipment to perform the work of the laboratory
- Make sure that appropriate chemicals, standards, and equipment is ordered to perform the work of the laboratory
- Supervise the technical staff of the laboratory

- Train the technical staff in the skills required to perform the technical aspects of the analyses

2.2 Training

Each employee has read, understood, and is using the latest version of the laboratory's SOPs, which relates to his/her job responsibilities. Each employee demonstrates continued proficiency by acceptable performance on Laboratory Control Sample (LCS). Training records (e.g., continuing education, participation in technical conferences, internal training activities) are kept with personnel files.

Initial Demonstration of Capabilities documentation can be found in the personnel files for the technical staff. Performance Testing, quality control samples, and internal audits are employed by RI Analytical Laboratories, Inc. (RIAL) management as a tool to train and educate the employees regarding the services and capabilities of RI Analytical Laboratories, Inc. (RIAL).

2.3 Laboratory Capabilities

RI Analytical Laboratories, Inc. (RIAL) analyzes water and soil samples. The table below lists the parameters/analytes measured.

Table 2-1 **RI Analytical Laboratories, Inc. Capabilities**

Parameter/Analyte	Methodology
PH	PH Meter
TSS	Gravimetric
Metals	ICP-OES
Metals	GFAA
Mercury	CVAA
Volatile Organics	GC/MS
Volatile Organics	GC
Semi-Volatile Organics	GC/MS
Ash	Gravity
Bulk Water & Sediment	Gravity
Flash Point	EPA SW-846
Reactivity, Cyanide	EPA SW-846
Reactivity, Sulfide	EPA SW-846
Nitrogen, Ammonia	Colorimetric
Nitrogen, Total Kjeldahl	Colorimetric
Nitrogen, Nitrate	Colorimetric
Nitrogen, Nitrite	Colorimetric
Odor	Olfactory
Fluoride	Colorimetric

Formaldehyde	HPLC
Hardness, Total	ICP
Moisture	Titration
Water, Karl Fisher	Titration
Water Reactivity	Colorimetric
Sulfur	Titration
Sulfate	Colorimetric/Gravimetric
Sulfide	Colorimetric
Sulfite	Colorimetric
Chlorine, free	Spectrophotometric
Chlorine, residual	Spectrophotometric
Chlorine Demand	Spectrophotometric
Chloride	Titration
Phenol	Colorimetric
Phosphate, Ortho	Colorimetric
Phosphate, Total	Colorimetric
Oil & Grease	GC, IR
Oxygen, Dissolved	Potentiometric
Sieve Analysis	Gravimetric
Specific Conductance	Potentiometric
Turbidity	Nephelometry
Biochemical Oxygen Demand	Potentiometric
Chemical Oxygen Demand	Colorimetric
Surfactants	IR, Spectrophotometric
Bromide	Colorimetric
Acidity	Titration
Alkalinity	Titration
Total Coliform	MF/MPN
Fecal Coliform	MF/MPN
Algae	Microscopic
Fecal Streptococcus	MF/MPN
Total Plate Count	Direct Plating
Salmonella Bacteria	MF/MPN
Legionella Bacteria	Direct Plating
Iron Bacteria	Microscopic
Enterococci	MF/MPN

3.0 QUALITY ASSURANCE OBJECTIVES

The overall QA objectives for RI Analytical Laboratories, Inc. is to develop and implement procedures for laboratory analysis, chain-of-custody, and reporting that will provide results which are of known and documented quality. Data Quality Indicators (DQIs) are used as qualitative and quantitative descriptors in interpreting the degree of acceptability or utility of data. The principal DQIs are precision, accuracy, reliability (in the form of representativeness, comparability, completeness) and detection limits. DQIs are used as quantitative goals for the quality of data generated in the analytical measurement process. This section summarizes how specific QA objectives are achieved. The specific application of these various activities are contained in the method SOPs.

Another goal of this Quality Assurance Program is to meet the requests of regulatory and accrediting bodies as well as RI Analytical Laboratories, Inc. customers. Management, administrative, statistical, investigative, preventive and corrective techniques will be employed to maximize reliability and representativeness of the data.

3.1 Precision

Precision is a measure of the degree to which two or more measurements are in agreement.

Precision is assessed through the calculation of relative percent differences (RPD) and relative standard deviations (RSD) for replicate samples. For inorganic analyses, laboratory precision is usually assessed through the analysis of a sample/sample duplicate pair and field duplicate pairs. For organic analyses, precision is usually assessed through the analysis of matrix spike/matrix spike duplicate (MS/MSD) and field duplicate samples.

3.2 Accuracy

Accuracy is the degree of agreement between an observed value and an accepted reference or true value.

Accuracy is assessed by the analysis of blanks and through the adherence to all sample handling, preservation and holding times. Laboratory accuracy is further assessed through the analysis of MS/MSD, quality control check samples, laboratory control samples (LCS) and surrogate compound spikes.

3.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition within a defined spatial and/or temporal boundary.

Representativeness is ensured by using the proper analytical procedures, appropriate methods, meeting sample holding times and analyzing field duplicate samples.

3.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions.

Laboratory completeness is a measure of the amount of valid measurements obtained from all the measurements taken in the project. The laboratory completeness objective is to generate valid data for all samples be greater than 95 percent.

3.5 Comparability

Comparability is an expression of the confidence with which one data set can be compared to another.

Comparability is achieved by the use of routine analytical methods, achieving holding times, reporting results in common units, use of consistent detection levels, and consistent rules for reporting data.

3.6 Detection Limits

Method Detection Limits (MDLs) are determined for all analytes as specified in the NELAC standards. From these, a Limit of Quantitation (LOQ), nominally 3.14 times the IDL, is established. The LOQ is the minimum concentration of an analyte that can be identified and quantified within specified limits of precision and bias during routine analytical operating conditions.

4.0 SAMPLING PROCEDURES

RI Analytical Laboratories, Inc. uses the sampling guidelines established in EPA SW-846 or in the absence of EPA sampling methods, American Society of Test Methods for specific analytes.

5.0 SAMPLE HANDLING

This section summarizes the RI Analytical Laboratories, Inc. policies and practices for sampling handling. Further details are contained in specific SOPs.

5.1 Sample Tracking

RI Analytical Laboratories, Inc. (RIAL) uniquely identifies each sample to be tested, to ensure that there can be no confusion regarding identity. The sample identification system includes identification for all samples, subsamples and subsequent extracts and/or digestates. A unique identification (ID) code is placed on each sample container.

5.2 Sample Acceptance Policy

RIAL has a written sample acceptance policy that outlines the circumstances under which samples will be accepted. Data from any samples, which do not meet the policy, are noted in the laboratory report defining the nature and substance of the variation. The policy requires:

- Proper, full, and complete documentation, including the sample identification, the location, date and time of collection, collector's name, preservation type, sample type and any special remarks concerning the sample;
- Unique identification of samples using durable labels completed in indelible ink;
- Use of appropriate sample containers;
- Receipt within holding times;
- Adequate sample volume; and
- Procedures that are used when samples show signs of damage or contamination.

5.3 Sample Receipt Protocols

Upon receipt, the condition of the sample, including any abnormalities or departures from standard condition is recorded. All samples which require thermal preservation are considered acceptable if the arrival temperature is either within +/-2 degrees C of the required temperature or the method specified range. For samples with a specified temperature of 4 degrees C, samples with a temperature of ranging from just above freezing temperature of water to 6 degrees C are considered acceptable. Samples that are hand delivered to the laboratory immediately after collection may not meet this criteria. In these cases, the samples will be considered acceptable if there is evidence that the chilling process has begun, such as arrival on ice.

Where applicable, RIAL verifies chemical preservation using readily available techniques, such as pH, free chlorine or temperature, prior to or during sample preparation or analysis. The results of checks are recorded.

Where there is any doubt as to the sample's suitability for testing, RIAL consults its clients for further instruction before proceeding. If the sample does not meet the sample receipt acceptance criteria, RIAL notes the condition of the samples on the chain of custody form and in the final report.

5.4 Storage Conditions

Samples which require thermal preservation are stored under refrigeration which is +/-2 degrees of the specified preservation temperature. For samples with a specified storage temperature of 4 degrees C, storage at a temperature above the freezing point of water to 6 degrees C is considered acceptable. Samples are stored in a manner that prevents cross contamination.

5.5 Chain of Custody

Chain of custody records are used to establish an intact, continuous record of the physical possession, storage and disposal of sample containers, collected samples, sample aliquots, and sample extracts or digestates. The COC records account for all time periods associated with the samples. The COC records identify all individuals who physically handled individual samples. The COC forms remain with the samples during transport or shipment. If shipping containers and/or individual sample containers are submitted with sample custody seals, and any seals are not intact, the lab shall note this on the chain of custody.

Access to all samples and subsamples is controlled. The laboratory area is restricted to authorized personnel only.

5.6 Sample Disposal

All samples, digestates, leachates and extracts or other sample preparation products are disposed of in accordance with Federal and State laws and regulations. If the sample is part of litigation, disposal of the physical sample occurs only with the concurrence of the affected legal authority, sample data user and/or submitter of the sample.

6.0 CALIBRATION PROCEDURES AND FREQUENCY

6.1 Traceability of Calibration

Wherever applicable, calibration of analytical support equipment and instruments is traceable to national standards of measurement.

6.2 Reference Standards

Reference standards of measurement (such as Class S or equivalent weights or traceable thermometers) are used for calibration only. Reference standards are subjected to in-service checks between calibrations and verifications.

6.3 General Requirements

Each calibration is dated and labeled with or traceable to the method, instrument, analysis date, and each analyte name, concentration and response (or response factor). Sufficient information is recorded to permit reconstruction of the calibration. Acceptance criteria for calibrations comply with method requirements or are established and documented.

6.4 Analytical Support Equipment

Analytical support equipment includes: balances, ovens, refrigerators, freezers, incubators, water baths, temperature measuring devices and volumetric dispensing devices if quantitative results are dependent on their accuracy, as in standard preparation and dispensing or dilution into a specified volume. All such support equipment is:

- maintained in proper working order. The records of all activities including service calls are kept.
- calibrated or verified at least annually, using NIST traceable references when available, over the entire range of use. The results of such calibration must be within the specifications required of the application for which the equipment is used or the equipment is removed from service until repaired.

Balances, ovens, refrigerators, freezers, incubators and water baths are checked with NIST traceable references (where possible) in the expected use range. The acceptability for use or continued use is according to the needs of the analysis or application for which the equipment is being used. Mechanical volumetric dispensing devices (except Class A glassware) are checked for accuracy quarterly.

6.5 Instrument Calibration

Calibration procedures for a specific laboratory instrument will consist of an initial calibration, and a calibration verification, when an initial instrument calibration is not performed on the day of analysis. The SOP for each analysis performed in the laboratory

describes the calibration procedures, their frequency, acceptance criteria and the conditions that will require recalibration. In all cases, the initial calibration is verified using an independently prepared calibration verification solution. RIAL maintains a sample logbook for each instrument which contains the following information: instrument identification, serial number, date of calibration, analyst, calibration solutions run and the samples associated with these calibrations.

All results are calculated based on the response curve from the initial calibration and are bracketed by calibration standards or reported as having a lower confidence level.

If the initial calibration fails, the analysis procedure is stopped and evaluated. For example, a second standard may be analyzed and evaluated or a new initial calibration curve may be established and verified. In all cases, the initial calibration must be acceptable before analyzing any samples.

When an initial instrument calibration is not performed on the day of analysis, a calibration verification check standard is analyzed at the beginning and at end of each batch. An exception to this policy is for internal standard methods (e.g. most organic methods). For these analyses, the calibration check is only analyzed at the beginning of the analytical sequence. The concentration of this calibration check varies on a daily basis as described in each method SOP. If a calibration check standard fails, and routine corrective action procedures fail to produce a second consecutive calibration check within acceptance criteria, a new initial calibration curve is constructed. If the continuing calibration acceptance criteria are exceeded high (i.e., high bias), and there are non-detects for the corresponding analyte in all environmental samples associated with the continuing calibration check, then those non-detects may be reported, otherwise the samples affected by the unacceptable check are reanalyzed after a new calibration curve has been established, evaluated and accepted. If the continuing calibration acceptance criteria are below the low limit, results may be reported if sample results indicate a concentration above an action level and accurate values are not required by the customer. Otherwise, additional sample analysis does not occur until a new calibration curve is established and verified.

7.0 TEST METHODS AND STANDARD OPERATING PROCEDURES

RIAL maintains Standard Operating Procedures (SOPs) that accurately reflect all laboratory activities such as assessing data integrity, corrective actions, handling customer complaints, and all test methods. Copies of SOPs are accessible to all personnel. Each SOP indicates the effective date, the revision number, and the signature(s) of the QC Coordinator, Laboratory Manager, and Vice President, Operations.

SOPs are used to ensure consistency and to save time and effort. Any deviation from an established procedure during an analysis is documented.

7.1 SOPs for Sample Management

These SOPs describe the receipt, handling, scheduling, and storage of samples.

Sample Receipt and Handling -- These procedures describe the precautions to be used in opening sample shipment containers and how to verify that chain-of-custody has been maintained, examine samples for damage, check for proper preservatives and temperature, and log samples into the laboratory sample streams.

Sample Scheduling -- These procedures describe the sample scheduling in the laboratory and includes procedures used to ensure that holding time requirements are met.

Sample Storage -- These procedures describe the storage conditions for all samples, verification and documentation of daily storage conditions, and how to ensure that custody of the samples is maintained while in the laboratory.

7.2 SOPs for Reagent/Standard Preparation

These SOPs describe how to prepare standards and reagents. Information concerning specific grades of materials used in reagent and standard preparation, appropriate glassware and containers for preparation and storage, and labeling and record keeping for stocks (ex. Lot# and Expiration dates) and dilutions is included. Upon receipt of every Reagent/Standard R.I. Analytical assigns an internal ID/tracking number on each individual container and in a logbook. This Id/tracking number will be documented anywhere the Reagent/standards are used.

7.3 SOPs for General Laboratory Techniques

These SOPs describe all essentials of laboratory operations that are not addressed elsewhere. These techniques should include, but are not limited to, glassware cleaning procedures, operation of analytical balances, pipetting techniques, use of volumetric glassware, pollution prevention, and waste management.

7.4 SOPs for Test Methods

1. Procedures for test methods describing how the analyses are actually performed in the laboratory are specified in method SOPs. These SOPs for sample preparation, cleanup and analysis are based on reference methods published by EPA, ASTM, AWWA, and other organizations and on internally developed methods validated according to EPA's Performance-Based Measurement System. Each method SOP includes(where applicable):
   1) identification of the test method;
   2) applicable matrix or matrices;
   3) method detection limit;
   4) scope and application, including components to be analyzed;
   5) summary of the method;
   6) definitions;
   7) interferences;
   8) safety;
   9) equipment and supplies;
   10) reagents and standards;
   11) sample collection, preservation, shipment and storage;
   12) quality control;
   13) calibration and standardization;
   14) procedure;
   15) calculations;
   16) method performance;
   17) data assessment and acceptance criteria for quality control measures;
   18) corrective actions for out-of-control data;
   19) contingencies for handling out-of-control or unacceptable data;
   20) references; and
   21) any tables, diagrams, flowcharts and validation data

7.5 SOPs for Equipment Calibration and Maintenance

These SOPs describe how to ensure that laboratory equipment and instrumentation are in working order. These procedures include calibration procedures and schedules, maintenance procedures and schedules, maintenance logs, service arrangements for all equipment, and spare parts available in-house. Calibration and maintenance of laboratory equipment and instrumentation are in accordance with manufacturers' specifications or applicable test specifications.

8.0 INTERNAL QUALITY CONTROL CHECKS

8.1 Laboratory Quality Control Samples

The data acquired from QC procedures are used to estimate the quality of analytical data, to determine the need for corrective action in response to identified deficiencies, and to interpret results after corrective action procedures are implemented. Each method SOP includes a QC section, which addresses the minimum QC requirements for the procedure. The internal QC checks may differ slightly for each individual procedure but in general are described below. The acceptance limits and corrective actions for these QC checks are described in Section 12 and 13 of this Manual.

a) Method Blanks are performed at a frequency of one per batch of samples per matrix type per sample extraction or preparation test method. The results of these samples are used to determine batch acceptance.

b) Laboratory Control Sample (QC Check Sample) are analyzed at a minimum of 1 per batch of 20 or fewer samples per matrix type per sample extraction or preparation method except for analytes for which spiking solutions are not available such as total suspended solids, total dissolved solids, total volatile solids, total solids, pH, color, odor, temperature, dissolved oxygen or turbidity. The results of these samples are used to determine batch acceptance.

c) Matrix Spikes (MS) are performed at a frequency of one in 20 samples per matrix type per sample extraction or preparation method except for analytes for which spiking solutions are not available such as, total suspended solids, total dissolved solids, total volatile solids, total solids, pH, color, odor, temperature, dissolved oxygen or turbidity. The sample(s) selected for spiking are rotated among received samples so that various matrix problems may be noted and/or addressed. Poor performance in a matrix spike generally indicates a problem with the sample composition, and not the laboratory analysis, and is reported to assist in data assessment.

d) Surrogates - Surrogate compounds are added to all samples, standards, and blanks for all organic chromatography test methods except when the matrix precludes its use or when a surrogate is not available. Poor surrogate recovery generally indicates a problem with the sample composition and is reported to assist in data assessment.

e) Spike Components - In general, all reportable components are in the spike mixes. However, in cases where the components interfere with accurate assessment (such as simultaneously spiking chlordane, toxaphene and PCBs in Method 608), the test method has an extremely long list of components (such as Methods 8270 or 6010) or components are incompatible, a representative number (10%) of the listed components are used. The selected components of each spiking mix represent all chemistries, elution patterns and masses and permit specified analytes and other client requested components. All reported components are used in the spike mixture within a two-year time period, and no one

component or components dominates the spike mixture.

f) Matrix Spike Duplicates (MSD) or Laboratory Duplicates are analyzed at a minimum of 1 in 20 samples per matrix type per sample extraction or preparation test method. The selected sample(s) are rotated among received samples so that various matrix problems may be noted and/or addressed. Poor performance in the duplicates generally indicates a problem with the sample composition and is reported to assist in data assessment.

8.2 Detection Limits

For analytes for which spiking is a viable option, detection limits are determined by a Method Detection Limit (MDL) study as described in by 40 CFR Part 136, Appendix B. The method detection limit is initially determined for the compounds of interest in each method in laboratory pure reagent water or Ottawa sand.

An MDL study is not performed for any component for which spiking solutions are not available such as total suspended solids, total dissolved solids, total volatile solids, total solids, pH, color, odor, temperature dissolved oxygen or turbidity. For these types of analytes, the detection limit is based on the signal to noise ratio from the analysis of a QC check sample or calibration standard.

A Reporting Limit is established by multiplying the MDL or other detection level times 3.14 and rounding to the nearest 1, 2, or 5.

8.3 Selectivity

a) Absolute and relative retention times aid in the identification of components in chromatographic analyses and help evaluate the effectiveness of a column to separate constituents. Acceptance criteria for retention time windows are documented in each method SOP.

b) A confirmation is performed to verify a compound identification when positive results are detected on a sample from a location that has not been previously tested. Such confirmations are performed on organic tests except when the analysis involves the use of a mass spectrometer.

c) Acceptance criteria for mass spectral tuning are contained in SOPs.

8.4 Demonstration of Method Capability

Prior to acceptance and use of any method, satisfactory initial demonstration of method performance is required. This initial demonstration of method performance is performed each time there is a significant change in instrument type, personnel or test method. The process is described in Appendix B. A Certification Statement is completed for each

analyst documenting that this activity has been performed. A copy of this statement is found in Appendix C.

9.0 DATA REDUCTION, REVIEW, REPORTING AND RECORDS

9.1 Data Reduction and Review

Data resulting from the analyses of samples is reduced according to protocols described in the laboratory SOPs. Computer programs used for data reduction are validated before use and verified regularly by manual calculations. All information used in the calculations (e.g., raw data, calibration files, tuning records, results of standard additions, interference check results, sample response, and blank or background-correction protocols) is recorded in order to enable reconstruction of the final result at a later date. Information on the preparation of the sample (e.g., weight or volume of sample used, percent dry weight for solids, extract volume, dilution factor used) is maintained in order to enable reconstruction of the final result at a later date.

Data is reviewed by a second analyst or supervisor according to laboratory procedures to ensure that calculations are correct and to detect transcription errors. Spot checks are performed on computer calculations to verify program validity. Errors detected in the review process are referred to the analyst(s) for corrective action.

As described in Section 12.0, the results of all quality control sample analyses are reviewed, and evaluated before data are reported.

9.2 Report Format and Contents

The results of each test, or series of tests are normally reported in a report and include all the information necessary for the interpretation of the results.

a) each report typically includes:
1) the title "Certificate of Analysis";
2) name and address of laboratory, and phone number with name of contact person;
3) a unique identification number and the total number of pages, with all pages sequentially numbered;
4) name and address of client;
5) description and unambiguous identification of the sample(s) including the client identification code;
6) identification of results for any sample that did not meet sample acceptance requirements;
7) date of receipt of sample, date and time of sample collection, and time of sample preparation and/or analysis if the required holding time for either activity is less than or equal to 48 hours;
8) identification of the test method used;

9) if the laboratory collected the sample, reference to sampling procedure;
10) any deviations from, additions to or exclusions from SOPs, and any conditions that may have affected the quality of results, and including the use and definitions of data qualifiers;
11) measurements, examinations and derived results, supported by tables, graphs, sketches and photographs as appropriate, and any failures identified; identification of whether data are calculated on a dry weight or wet weight basis; identification of the reporting units such as µg/l or mg/kg;
12) clear identification of all test data provided by outside sources, such as subcontracted laboratories, clients, etc.; and
13) clear identification of numerical results with values below the Reporting Limit

Exceptions to this standard approach for reporting are allowed with approval of the Vice President, Operations and are documented.

Material amendments to a test report after issue are made only in the form of a further document, or data transfer including the statement "Supplement to Test Report, identification number."

Clients are notified promptly, in writing, of any event such as the identification of defective measuring or test equipment that casts doubt on the validity of results given in any test report or amendment to a report.

Test results are certified to meet all requirements of the NELAC standards, or reasons are provided if they do not.

9.3 Records

Records provide the direct evidence and support for the necessary technical interpretations, judgments, and discussions concerning laboratory results. These records, particularly those that are anticipated to be used as evidentiary data, provide the historical evidence needed for later reviews and analyses. Records should be legible, identifiable, and retrievable, and protected against damage, deterioration, or loss. All records referenced in this section are retained for a minimum of ten years.

Laboratory records generally consist of bound notebooks with pre-numbered pages, personnel qualification and training forms, equipment maintenance and calibration forms, chain-of-custody forms, sample analysis request forms, and analytical change request forms. All records are recorded in indelible ink and retained for five years. Records that are stored or generated by computers or personal computers (PCs) have hard copy or write-protected backup copies.

Any documentation errors are corrected by drawing a single line through the error so that it remains legible and is initialed by the responsible individual, along with the date of change. The correction is written adjacent to the error. Strip-chart recorder printouts are signed by the person who performed the instrumental analysis. If corrections need to be made in

computerized data, a system parallel to the corrections for handwritten data is used.

If any change is made to any record it needs to be signed or initialed by the responsible individual, along with the reason for the change "per customer", "sampled by", "reviewed by".

Laboratory records include the following:

Standard Operating Procedures -- Any revisions to laboratory procedures are written, dated, and distributed to all affected individuals to ensure implementation of changes.

Equipment Maintenance Documentation -- Documents detailing the receipt and specification of analytical equipment are retained. A history of the maintenance record of each system serves as an indication of the adequacy of maintenance schedules and parts inventory. As appropriate, the maintenance guidelines of the equipment manufacturer are followed. When maintenance is necessary, it is documented in either standard forms or in logbooks.

Calibration Records & Traceability of Standards/Reagents -- The frequency, conditions, standards, and records reflecting the calibration history of a measurement system are recorded.

Sample Management -- A record of all procedures to which a sample is subjected while in the possession of the laboratory is maintained. These include records pertaining to:
a) Sample preservation including appropriateness of sample container and compliance with holding time requirement;
b) Sample identification, receipt, acceptance or rejection and log-in;
c) Sample storage and tracking including shipping receipts, transmittal forms, and internal routing and assignment records;
d) Disposal of hazardous samples including the date of sample or subsample disposal and name of the responsible person;
e) Automated sample handling systems.

Original Data -- The raw data and calculated results for all samples are maintained in laboratory notebooks, logs, bench sheets, files or other sample tracking or data entry forms. Instrumental output is stored in a computer file or a hard copy report. These records include:
a) Laboratory sample ID code;
b) Date of analysis;
c) Instrumentation identification and instrument operating conditions/parameters;
d) Analysis type and sample preparation information, including sample aliquots processed, cleanup, and separation protocols;
e) All manual, automated, or statistical calculations;
f) Confirmatory analysis data, when required to be performed;
g) Review history of sample data; and

f) Analyst's or operator's initials/signature.

QC Data -- The raw data and calculated results for all QC samples and standards are maintained in the manner described in the preceding paragraph. Documentation allows correlation of sample results with associated QC data. Documentation also includes the source and lot numbers of standards for traceability. QC samples include, but are not limited to, control samples, method blanks, matrix spikes, and matrix spike duplicates.

Correspondence -- Correspondence pertinent to a project is kept and placed in the project files.

Deviations -- All deviations from SOPs. Deviations are reviewed and approved by the QA Officer or Technical Director.

Final Report -- A copy of any report issued and any supporting documentation.

Administrative Records -- The following are maintained:
a) Personnel qualifications, experience and training records;
b) Initial and continuing demonstration of proficiency for each analyst; and
c) A log of names, initials and signatures for all individuals who are responsible for signing or initialing any laboratory record.

9.4 Document Control System

A document control system is used to ensure that all staff has access to current policies and procedures at all times. Documents, which are managed by this system, include this Quality Manual and all SOP's. The system consists of a document review, revision and approval system, and, document control and distribution.

All quality documents (this Manual, SOPs, policies, etc.) are reviewed and approved by the QA Coordinator, the Laboratory Manager and the Vice President, Operations. Such documents are revised whenever the activity described changes significantly. All documents are reviewed at least every 5 years.

The QA Coordinator controls all quality documents. Controlled copies are provided to individuals in the laboratory who need copies. The QA Coordinator maintains a distribution list for controlled copies and ensures that any revisions are distributed appropriately.

9.5 Confidentiality

All laboratory results and associated raw data are kept in confidence to the customer who requested the analyses. Access to laboratory records and LIMS data is limited to laboratory personnel except with the permission of the QA Coordinator or Vice President, Operations. NELAP-related records are made available to authorized accrediting authority personnel.

Where clients require transmission of test results by telephone, telex, facsimile or other electronic or electromagnetic means, staff will ensure confidentiality is preserved.

10.0 PERFORMANCE AND SYSTEM AUDITS AND FREQUENCY

10.1 Internal Laboratory Audits

Annual internal audits are performed to verify that laboratory operations continue to comply with the requirements of the quality system. Audits are performed by the Quality Control Coordinator. Where the audit findings cast doubt on the correctness or validity of the laboratory's results, an immediate corrective action is initiated and any client whose work may have been affected is notified.

The internal system audits include an examination of laboratory documentation on sample receiving, sample log-in, sample storage, chain-of-custody procedures, sample preparation and analysis, instrument operating records and Certificate of Analysis.

10.2 Managerial Review

At least once per year, laboratory management conducts a review of the quality system to ensure its continuing suitability and effectiveness and to introduce any necessary changes or improvements in the quality system and laboratory operations. The review takes account of reports from managerial and supervisory personnel, the outcome of recent internal audits, assessments by external bodies, the results of proficiency tests, any changes in the volume and type of work undertaken, feedback from clients, corrective actions and other relevant factors.

11.0 FACILITIES, EQUIPMENT, REAGENTS, AND PREVENTATIVE MAINTENANCE

11.1 Equipment and Reference Materials

Records are maintained for major equipment and all reference materials significant to the tests performed. These records include documentation on routine and non-routine maintenance activities and reference material verifications.
The records include:

1) the name of the equipment;
2) the manufacturer's name, type identification, and serial number or other unique identification;
3) date received and date placed in service (if available);
4) current location, where appropriate;
5) if available, condition when received (e.g. new, used, reconditioned);
6) copy of the manufacturer's instructions, where available;
7) dates and results of calibrations;
8) details of maintenance carried out to date and planned for the future; and
9) history of any damage, malfunction, modification or repair.

Glassware Cleaning - Glassware is cleaned to meet the sensitivity of the method. Any cleaning and storage procedures that are not specified by the method are documented in laboratory records and SOPs.

11.2 Documentation and Labeling of Standards and Reagents

Records are kept for all standards, including the manufacturer/vendor, the manufacturer's Certificate of Analysis or purity (if supplied), the date of receipt, recommended storage conditions, and an expiration date after which the material is not used unless it is verified.

Original containers provided by the vendor are labeled with an expiration date or a date of receipt.

Detailed records are maintained on reagent and standard preparation. These records indicate traceability to purchased stocks or neat compounds, reference to the method of preparation, date of preparation, expiration date and initials of the individual preparing the standard or reagent.

All containers of prepared reagents and standards bear a unique identifier and expiration date and are linked to the documentation requirements above.

1) Reagents - In methods where the purity of reagents is not specified, analytical reagent grade shall be used. Reagents of lesser purity than those specified by the method are not to be used. The labels on the container are checked to verify that the purity of the reagents meets the requirements of the particular method. Such information is documented.

2) Water - The quality of reagent water sources is monitored and documented to meet method specified requirements.

11.3 Computers and Electronic Data Related Requirements

Where computers or automated equipment are used for the capture, processing, manipulation, recording, reporting, storage or retrieval of test data:

- Section 8.1 through 8.11 of the EPA Document "2185 - Good Automated Laboratory Practices" (1995), is used as the standard.
- computer software is documented to be adequate for use;
- procedures are established and implemented for protecting the integrity of data;
- computer and automated equipment are maintained to ensure proper functioning;
- appropriate procedures are used for the maintenance of security of data including the prevention of unauthorized access to, and the unauthorized amendment of, computer records.

11.4 Preventative Maintenance

A routine preventative maintenance program is used to minimize the occurrence of instrument failure and other system malfunctions. Designated laboratory employees regularly perform routine scheduled maintenance and repair of instruments, where applicable. All maintenance that is performed is documented in the laboratory's operating record. All laboratory instruments are maintained in accordance with manufacturer's specifications.

11.5 Inspection/Acceptance Requirements for Supplies and Consumables

Labels indicating the following information on receipt and testing are to be used for critical supplies and consumables.

- Unique identification number (if not clearly shown).
- Date received.
- Date opened.
- Date tested (if performed).
- Date to be retested (if applicable).
- Expiration date.

12.0 SPECIFIC ROUTINE PROCEDURES USED TO EVALUATE DATA QUALITY

Quality control acceptance criteria are used to determine the validity of the data based on the analysis of internal quality control check (QC) samples (see Section 8.0). The specific QC samples and acceptance criteria are found in the laboratory SOPs. Typically, acceptance criteria are taken from published EPA methods. Where no EPA criteria exist, laboratory generated acceptance criteria are established. Acceptance criteria for accuracy (bias) are based on the historical mean recovery plus or minus three standard deviation units, and acceptance criteria for precision range from zero (no difference between duplicate control samples) to the historical mean relative percent difference plus three standard deviation units, where applicable to the specific test method.

Analytical data generated with QC samples that fall within prescribed acceptance criteria indicate the laboratory was in control. Data generated with QC samples that fall outside the established acceptance criteria indicate the laboratory was "out-of-control" for the failing tests. These data are considered suspect and the corresponding samples are reanalyzed or reported with qualifiers.

Many published EPA methods do not contain recommended acceptance criteria for QC sample results. In these situations, RIAL uses 70 - 130% as interim acceptance criteria for recoveries of spiked analytes, until in-house limits are developed. In-house limits are based on a 95% confidence interval and must include a minimum of 10 data points.

12.1 Laboratory Control Samples

A laboratory control sample (LCS) is analyzed with each batch of 20 samples to verify that the accuracy of the analytical process is within the expected performance of the method. The results of the laboratory control sample are compared to acceptance criteria to determine usability of the data. Data generated with LCS samples that fall outside the established acceptance criteria are judged to be out-of-control. These data are considered suspect and the corresponding samples are reanalyzed or reported with qualifiers.

12.2 Matrix Spikes/Matrix Spike Duplicates

Results from MS/MSD analyses are primarily designed to assess data quality in a given matrix, and not laboratory performance. In general, if the LCS results are within acceptance criteria, performance problems with MS/MSD results may either be related to the specific sample matrix or to an inappropriate choice of extraction, cleanup, or determinative methods. If any individual percent recovery in the matrix spike (or matrix spike duplicate) falls outside the designated acceptance criteria, RIAL will determine if the poor recovery is related to a matrix effect or a laboratory performance problem. A matrix effect is indicated if the LCS data are within acceptance criteria but the matrix spike data exceed the acceptance criteria.

12.3 Surrogate Recoveries

Surrogates are exclusively used in organic analyses. Surrogate recovery data from individual samples are compared to surrogate recovery acceptance criteria in the methods. As for MS/MSD results, surrogate recoveries are used primarily to evaluate data quality and not laboratory performance.

12.4 Method Blanks

Method blank analyses are used to assess acceptance of sample results. The source of contamination is investigated and measures taken to correct, minimize or eliminate the problem if:

- the blank contamination exceeds a concentration greater than 1/10 of the measured concentration of any sample in the associated sample batch or
- the blank contamination exceeds the concentration present in the samples and is greater than 1/10 of the specified regulatory limit.

Each sample in the affected batch is assessed against the above criteria to determine if the sample results are acceptable. Any sample associated with the contaminated blank is reprocessed for analysis or the results reported with appropriate data qualifying codes.

13.0 CORRECTIVE ACTION

Corrective action is the process of identifying, recommending, approving and implementing measures to counter unacceptable procedures or out of control QC performance that can affect data quality. To the extent possible, samples are reported only if all quality control measures are acceptable. If a quality control measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure are reported with the appropriate data qualifier(s). Sample results may also be qualified when holding times are not met, improper sample containers and/or preservatives or used or when other deviations from laboratory standard practices and procedures occur.

Corrective action in the laboratory may occur prior to, during and after initial analyses. A number of conditions such as broken sample containers, multiple phases, low/high pH readings, and potentially high concentration samples may be identified during sample log-in or just prior to analysis. The SOPs specify conditions during or after analysis that may automatically trigger corrective action or optional procedures. These conditions may include dilution of samples, additional sample extract cleanup, and automatic reinjection/reanalysis when certain QC criteria are not met.

Any QC sample result outside of acceptance limits requires corrective action. Once the problem has been identified and addressed, corrective action may include the reanalysis of samples, or appropriately qualifying the results.

The analyst will identify the need for corrective action. Laboratory Manager will approve the required corrective action to be implemented by the laboratory staff. The QC Coordinator will ensure implementation and documentation of the corrective action.

Corrective actions are performed prior to release of the data from the laboratory. The corrective action will be documented in both a corrective action log (signed by analyst, the Laboratory Manager, and QC Coordinator), and the narrative in data report.

Where a complaint, or any other circumstance, raises doubt concerning the laboratory's compliance with the laboratory's policies or procedures, or with the quality of the laboratory's tests, the laboratory shall ensure that those areas of activity and responsibility involved are promptly audited. Records of the complaint and subsequent actions are maintained.

All client and internal Corrective Actions Requests (C.A.R.) are logged in to the C.A.R. log located on the computer network and hard copy in the QA/QC Office. There is an individual identification number assigned to new C.A.R. The C.A.R. request is given to the Lab Manager for an inquiry and response. Upon review and completion of the C.A.R. request by the Lab Manager a response is given to the QA/QC Coordinator. The QA/QC Coordinator issues a formal letter to the customer addressing the C.A.R. issue. A follow up is conducted with the Lab Manager.

14 SUBCONTRACTING AND SUPPORT SERVICES AND SUPPLIES

14.1 Subcontracting Laboratory Services

Clients are advised if any analyses will be subcontracted to another laboratory. Any subcontracted work is placed with another NELAC accredited laboratory for the tests to be performed. The following records of all subcontracted analyses are maintained:

- a copy of the subcontracted laboratory's scope of accreditation
- a copy of the report from the subcontracted laboratory
- the notice to the client.

14.2 Outside Support Services and Supplies

RIAL only uses those outside support services and supplies that are of adequate quality to sustain confidence in the laboratory's tests. Records of all suppliers for support services or supplies required for tests are maintained.

15.0 REFERENCES

NELAC Standards, July 1999*

Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80, December 29, 1980, Office of Monitoring Systems and Quality Assurance, ORD, U.S. EPA, Washington, DC 20460.

RCRA QAPP Instructions, U. S. EPA Region 5, Revision: April 1998*

ASTM D-5283-92.Generation of Environmental Data Related to Waste Management Activities: Quality assurance and Quality Control Planning and Implementation

"American National Standards Specification and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs (ANSI/ASQC E-4)", 1994

EPA 2185 - Good Automated Laboratory Practices, 1995*

ISO/IEC Guide 25: 1990. General requirements for the competence of calibration and testing laboratories

QA/R-2: EPA Requirements for Quality Management Plans, August, 1994*

QA/G-4: Guidance for the Data Quality Objectives Process EPA/600/R-96/055, September 1994*

QA/R-5: EPA Requirements for Quality Assurance Project Plans Draft - November 1997*

QA/G-5: Guidance on Quality Assurance Project Plans EPA/600/R-98/018, February 1998*

QA/G-6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995*

QA/G-9: Guidance for the Data Quality Assessment: Practical Methods for Data Analysis EPA/600/R-96/084, January, 1998*

Manual for the Certification of Laboratories Analyzing Drinking Water EPA/570/9-90/008*

APPENDIX A: CERTIFICATION STATEMENT

NELAC CERTIFICATION STATEMENT

The applicant understands and acknowledges that RI Analytical Laboratories, Inc. is required to be continually in compliance with the National Environmental Laboratory Accreditation Conference (NELAC) standards and shall be subject to the penalty provisions provided therein.

I hereby certify that I am authorized to sign this application on behalf of the applicant/owner and that there are no misrepresentations in my answer to the questions on this application.

RI Analytical Laboratories, Inc.

_____	_____	_____
Signature Laboratory Manager	Name	Date
_____	_____	_____
Signature Quality Control Coordinator	Name	Date
_____	_____	_____
Signature Vice President, Operations	Name	Date

APPENDIX B: INITIAL DEMONSTRATION OF CAPABILITY

A demonstration of capability (DOC) is made prior to using any test method, and at any time there is a significant change in instrument type, personnel or test method.

All demonstrations are documented through the use of the form in this appendix.

The following steps are performed.

a) A quality control sample is obtained from an outside source. If not available, the QC sample is prepared by the laboratory using stock standards that are prepared independently from those used in instrument calibration.

b) The analyte(s) are diluted in a volume of clean matrix sufficient to prepare four aliquots at the concentration specified, or if unspecified, to a concentration approximately 10 times the laboratory-calculated detection limit.

c) Four aliquots are prepared and analyzed according to the test method either concurrently or over a period of days.

d) Using all of the results, the mean recovery and the standard deviation is calculated for each parameter of interest.

e) The calculated mean and standard deviation are compared to the corresponding acceptance criteria for precision and accuracy in the test method (if applicable) or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters does not meet the acceptance criteria, the performance is unacceptable for that parameter.

f) When one or more of the tested parameters fail at least one of the acceptance criteria, the laboratory repeats the test for all parameters that failed to meet criteria. If repeated failure occurs, the laboratory will locate and correct the source of the problem and repeat the test for all compounds of interest beginning with c).

CERTIFICATION STATEMENT

The following certification statement is used to document the completion of each demonstration of capability. A copy of the certification statement is retained in the personnel records of each affected employee.

APPENDIX C: CERTIFICATION STATEMENT FOR METHOD VALIDATION

INITIAL DEMONSTRATION OF CAPABILITY CERTIFICATION STATEMENT

Date: _____

RI Analytical Laboratories, Inc.
41 Illinois Ave.
Warwick, RI 02888

Analyst Name: _____

Matrix: __Laboratory pure reagent water __Ottawa sand

Method and Analyte: _____

We, the undersigned, CERTIFY that:

1. The analyst identified above, using the cited test method, which is in use at this facility for the analyses of samples under the National Environmental Laboratory Accreditation Program, have met the Initial Demonstration of Capability.
2. The test method was performed by the analyst identified on this certification.
3. A copy of the laboratory-specific SOPs is available for all personnel on-site.
4. The data associated with the initial demonstration capability are true, accurate, complete and self-explanatory (1).
5. All raw data (including a copy of this certification form) necessary to reconstruct and validate these analyses have been retained at the facility, and, the associated information is well organized and available for review by authorized inspectors.

_____	_____	_____
Laboratory Manager's Name	Signature	Date
_____	_____	_____
Quality Control Coordinator Name	Signature	Date

(1)True: Consistent with supporting data.
Accurate: Based on good laboratory practices consistent with sound scientific principles/practices.
Complete: Includes the results of all supporting performance testing.
Self-explanatory: Data properly labeled and stored so that the results are clear and require no additional explanation.

Supplemental Appendices

APPENDIX D
GUIDANCE FOR THE PREPARATION OF STANDARD OPERATING PROCEDURES (SOPs)

Title Page
The first page of each SOP should be a title page having the following information: a title that clearly identifies the activity or procedure, the name of the laboratory, and the date and signatures of those individuals who prepared and approved the SOP.

Table of Contents
A Table of Contents is needed only if the SOP is longer than ten pages.

Control Documentation
Each page of the SOP should have control documentation, as illustrated below, generally in the upper right hand corner. A short title can identify the activity covered by the SOP and serve as a reference designation. The revision number and date are useful in identifying the SOP in use when reviewing historical data. The user can also quickly check if the SOP is complete when the number of pages is indicated. Suggested control documentation format:

Short Title
Rev. #: 0
Date: July 1995
Page 1 of 6

Text
The text of an SOP should be clearly worded so as to be readily understandable by a person knowledgeable with the general concept of the procedure. The procedures should be written in a step-by-step (cookbook) format that clearly describes the steps in chronological order. Use the active voice and present verb tense. The term "you" should not be used, but implied.

An SOP can reference other SOPs. In such a case, cite the other SOP or attach a copy.

Checklists

Many activities use checklists to ensure that steps are followed in order. Checklists also document completed actions. Any checklists or forms that are included as part of an activity should be referenced at the points in the procedure where they are used; blank and completed copies of the checklists should be attached to the SOP.

In some cases, detailed checklists are prepared specifically for a given activity, as for an inspection. In those cases, the SOP should describe, at least generally, how the checklist is to be prepared, or on what it is to be based. Copies of specific checklists are then maintained in the file with the activity results and/ or with the SOP. Remember that the checklist is not an SOP, but a part of one.

Types of SOPs
An SOP may be written for a repetitive administrative procedure as well as for a technical activity. Examples are: QA procedures for conducting assessments; equipment use; maintenance and calibration; and, collection of samples. General guidance for preparing both Technical and Administrative SOPs follow.

Suggested Format for a Technical SOP

Procedural Section:
After the title page, the following are topics that may be appropriate for inclusion in a technical SOP:

- Scope & Applicability,
- Summary,
- Definitions (acronyms, abbreviations and specialized forms used in the SOP),
- Health & Safety Warnings (indicating operations that could result in personal injury or loss of life and explaining what will happen if the procedure is not followed or is followed incorrectly; listed here and at the critical steps in the procedure),
- Cautions (indicating activities that could result in equipment damage, degradation of sample or possible invalidation of results; listed here and at the critical steps in the procedure),
- Interferences,
- Personnel Qualifications,
- Apparatus & Materials (list or specify; note also designated locations where found),
- Instrument or Method Calibration,
- Sample Collection,
- Handling & Preservation,
- Sample Preparation and Analysis,
- Troubleshooting,
- Data Acquisition, Calculations & Data Reduction,
- Computer Hardware & Software (used to manipulate analytical results and report data), and
- Data Management & Records Management

Quality Control and Quality Assurance Section
QC activities are designed to allow self- verification of the quality and consistency of the work. Describe the preparation of appropriate QC procedures (self-checks, such as calibration) and QC material (such as blanks - rinsate/trip/field/method, replicates, splits and spiked samples, and performance evaluation samples) that are required to successfully demonstrate performance of the method. Specific criteria for each should be included. Describe the frequency of required calibration and QC checks and discuss the rationale for decisions. Describe the limits/criteria for QC data/results and actions required when QC data exceed QC limits or appear in the warning zone. Describe the procedures for reporting QC data/results.

Specify and describe any QA procedures that are integral parts of the activity, including performance audits, outside audits or reviews, or other activities. These can be referenced from the organization's QMP. Specify who or what organization is responsible for each QA activity, where or how QA materials are to be procured and/or verified. Assign responsibility for taking corrective action, based on the results of the QA activities.

Reference Section

Documents or procedures that interface with the SOP should be fully referenced (including version), such as related SOPs and published literature or methods manuals. Citations cannot substitute for the description of the method being followed in the organization. Fully cite all references noted in the body of the SOP and attach any that are not readily available.

Suggested Format for an Administrative SOP

When auditing, reviewing, and/or inspecting the work of others, the SOP needs to include a number of specific steps aimed at making initial contact with the subject of the activity, coordinating the activity, and reporting. An SOP for a general activity (e. g., a management systems review or laboratory audit) should be covered by SOP guidance tailored to that activity. The SOP guidance should fit within the framework presented here, but can be modified, reduced, or expanded.

Procedural Section

The following are topics that may be appropriate for inclusion in an administrative SOP:

- Title,
- Purpose,
- Applicability,
- Summary of Procedure,
- Definitions,
- Personnel Qualifications, and
- Procedure.

Audits or assessment SOPs should specify the authority for the assessment, how targets of the audits are to be selected, what will be done with the results, and who is responsible for corrective action.

Quality Control and Quality Assurance Section

Describe any control steps and provisions for review or oversight prior to acceptance of the product or deliverable. This can include test plans such as verification and validation plans for software.

Reference Section

Cite all references noted in the body of the SOP. A copy of any cited references not readily

available should be attached to the SOP.

List of SOPs

Preparation, Approval, Distribution, and Revision of Standard Operation Procedures
Sample Receiving, Acceptance, Preservation, and Handling
Log-in
Corrective Action
Document Control
Internal Laboratory Data Review
Logbook Maintenance, Utilization, and Review
D.I. Water Quality Checks
Analytical Balance Calibration and Checks
Thermometer Calibration
Oven, Refrigerator, and Freezer Temperature Checks
Customer Complaints
Internal Audits
Reviewing New Work
Quality in Purchasing
External Laboratory Records Storage and Retrieval
Internal Laboratory Records Storage and Retrieval
Use of the LIMS Training Log (GALP related)
Logging a Sample Into LIMS (GALP related)
Scheduling and Updating Sample Status in LIMS (GALP related)
Manual Data Entry into LIMS (GALP related)
LIMS and Chem-Server Maintenance (GALP related)
Retention and Back-up of LIMS Raw Data on Other Electronic Media (GALP related)
Glassware Cleaning
Standard Naming of Compounds (LIMS related)
Sample Bottle Cleaning and Preparation
Protection of Client Confidential Information & Proprietary Rights
Testing of Proficiency Test Samples
Management System Reviews (MSR)
Nonconformity
Taking Representative Samples & Sub-samples in the Laboratory
Waste Disposal SOP's
Sample Acceptance & Rejection

APPENDIX E
Environmental Monitoring Management Council
Format for Analytical Methods

In accordance with EMMC format, each analytical method must contain 17 specific topical sections in a designated order. All of these sections are mandatory for all methods.

1.0 Scope and Application
2.0 Summary of Method
3.0 Definitions
4.0 Interferences
5.0 Safety
6.0 Equipment and Supplies
7.0 Reagents and Standards
8.0 Sample Collection, Preservation, and Storage
9.0 Quality Control
10.0 Calibration and Standardization
11.0 Procedure
12.0 Data Analysis and Calculations
13.0 Method Performance
14.0 Pollution Prevention
15.0 Waste Management
16.0 References
17.0 Tables, Diagrams, Flowcharts, and Validation Data

NELAC	EMMC Section
1) identification of the test method	**1.0**
2) applicable matrix or matrices	**1.0**
3) method detection limit	**1.0/17.0**
4) scope and application, including components to be analyzed	**1.0**
5) summary of the test method	**2.0**
6) definitions	**3.0**
7) interferences	**4.0**
8) safety	**5.0**
9) equipment and supplies	**6.0**
10) reagents and standards	**7.0**
11) sample collection, preservation, shipment and storage	**8.0**
12) quality control	**9.0**
13) calibration and standardization	**10.0**
14) procedure	**11.0**
15) calculations	**12.0**
16) method performance	**13.0**
17) pollution prevention	**14.0**
18) data assessment and acceptance criteria for quality control measures	**9.0**
19) corrective actions for out-of-control data	**9.0**
20) contingencies for handling out-of-control or unacceptable data	**9.0**
21) waste management	**15.0**
22) references	**16.0**
23) tables, diagrams, flowcharts and validation data	**17.0**

1.0 Scope and application

This section outlines the purpose, range, limitations, and intended use of the method, and identifies target analytes.

1.1 Define the purpose and intended use of the method. State what the method is based upon, noting any relationship of the method to other existing analytical methods. Indicate whether the method is associated with a sampling method.

1.2 List analytes that can be measured by the method, including each analyte's Chemical Abstracts Service Registry Number (CASRN). If regulations cite other than the most commonly used analyte name, refer to the regulation. For pesticides, use "acceptable common names." The use of registered trade names is permitted.

1.3 Identify the matrix(ces) for which the method has been found satisfactory.

1.4 Indicate the statistically determined method detection limit (MDL) and the analyte concentration range over which the method is applicable. State the matrix(ces) in which MDL was determined. If the MDL is not available, report an instrumental detection limit and define how it was derived.

1.5 Describe method limitations, such as "This method is not applicable to saline water," or "This method is not intended for determination of metals at concentrations normally found in treated and untreated discharges from industrial facilities." Indicate any means of recognizing cases where the method may not be applicable to the sample under test.

1.6 List any restrictions that may apply, such as "This method is restricted to use by or under the supervision of analysts experienced in . . ."

1.7 Include the following statement: "Each laboratory that uses this method must demonstrate the ability to generate acceptable results using the procedure in Section 9.1.2."

2.0 Summary of method

This section provides an overview of the method procedure and quality assurance.

2.1 Outline, specifying amounts of sample and reagent, the procedure that is followed to determine the presence or absence of the listed analytes. Include any sample pretreatment, such as filtration or digestion. In this description, identify the basic steps involved in performing the method, but omit the details that are a necessary part of the complete statement of procedure.

2.1.1 For chemical methods, state the type of procedure (colorimetric, electrometric, volumetric, etc.) and describe the source of color, major chemical reaction, including pertinent chemical equations, etc. For instrumental methods, state the technique.

2.1.2 In the "Summary of Method" section, use the passive voice, e.g., "Instrumental drift is corrected by using internal standardization," rather than "Correct instrumental drift by using internal standardization."

2.2 Identify the determinative step in the method.

2.3 State in a summary fashion how quality is assured in the method.

2.4 List options to the method, if applicable.

3.0 Definitions

This section includes definitions of terms, acronyms, and abbreviations used in the method. If preferred, definitions may be provided in a glossary at the end of the method or manual. In this case, the definitions section must still appear in the method, with a notation that definitions are provided in a glossary at the end of the method. Refer to the specific section number of the glossary.

3.1 Include an introductory statement as follows: "The definitions and purposes below are specific to this method, but have been conformed to common usage as much as possible."

3.2 List units of weight and measure and their abbreviations or acronyms used in the method.

3.3 Alphabetically list and define terms, acronyms, and abbreviations used in the method. Where appropriate, include the purpose (e.g., The purpose of the field blank is to determine if the field or sample transporting procedures and environments have contaminated the sample).

3.4 Include definitions of the terms may, may not, must, and should, as follows:

3.4.1 May: This action, activity, or procedural step is neither required nor prohibited.

3.4.2 May not: This action, activity, or procedural step is prohibited.

3.4.3 Must: This action, activity, or procedural step is required.

3.4.4 Shall: This action, activity, or procedural step is required.

3.4.5 Should: This action, activity, or procedural step is suggested but not required.

4.0 Interferences

This section identifies known or potential interferences that may occur during use of the method, and describes ways to reduce or eliminate interferences.

4.1 Describe any known or potential problem(s) (e.g., sample or equipment contamination, instrument noise) that may be encountered during the performance of the method and the source of the problem(s). Recommend techniques to avoid or minimize the problem(s) (e.g., ways to reduce sample or equipment contamination, or instrument noise).

4.2 Identify any substances, ions, or properties that are known to or likely to cause interference and the amounts that are known to or likely to interfere. Sometimes, this information can be obtained only by observation during the analysis. In such cases, include appropriate notes under "Procedure" or "Data Analysis and Calculations."

5.0 Safety

This section describes special precautions needed to ensure personnel safety during the performance of the method. Procedures described here should be limited to those which are above and beyond good laboratory practices. The section must contain information regarding specific toxicity of analytes or reagents.

5.1 Identify and warn analysts of potential hazards associated with using the method (e.g., toxicity or carcinogenicity of analytes or reagents, explosions, fire, radiation). Recommend techniques to minimize hazards where possible (e.g., performing operations in a hood or glove box).

5.2 Where the toxicity or carcinogenicity of each compound or reagent has not been precisely determined, include the following statement: "The toxicity or carcinogenicity of each analyte or reagent has not been precisely determined; however, each chemical should be treated as a potential health hazard. Exposure to these chemicals should be reduced to the lowest possible level. It is suggested that the laboratory perform personal hygiene monitoring of each analyst using this method and that the results of this monitoring be made available to the analyst."

5.3 Indicate the steps in the procedure at which hazards that could damage equipment may occur by use of the word CAUTION in boldface type, followed by the details of the precautionary measures that must be

taken. If any step in the procedure could result in personal injury or death, include the word WARNING in boldface type, followed by the details of the protective measures that must be taken.

5.4 Include the following statements: "This method does not address all safety issues associated with its use. The laboratory is responsible for maintaining a safe work environment and a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of material safety data sheets (MSDS) is available to all personnel involved in these analyses. Additional information on laboratory safety can be found in References ____."

6.0 Equipment and supplies

This section lists and describes all nonconsumable supplies and equipment needed to perform the method.

6.1 Include the following statement as a note preceding the list of equipment and supplies: "Note: Brand names, suppliers, and part numbers are cited for illustrative purposes only. No endorsement is implied. Equivalent performance may be achieved using equipment and materials other than those specified here, but demonstration of equivalent performance that meets the requirements of this method is the responsibility of the laboratory."

6.2 Categorize and list required equipment and supplies by the logical order of use; e.g., sampling equipment, equipment for glassware cleaning, equipment for calibration, equipment for sample extraction, etc. Do not list common laboratory equipment, but do include special or modified forms of unusual sizes or numbers of common equipment that are required or that may require special preparation.

6.3 Describe the essential features of each required item. Include schematic drawings as needed to clarify or supplement apparatus descriptions.

6.4 Avoid the use of trademarks, brand names, trade names, or suppliers unless a specific manufacturer's product is required for a well-defined reason or the availability of the product is limited (i.e., the apparatus is unique or unusual). For example, when special types of glassware are required, such as heat-resistant, chemical-resistant, etc., state the significant characteristic desired rather than a trademark ("borosilicate glass" rather than Pyrex or Kimax). If only a single source is known, that supplier may be identified.

6.5 Whenever a brand name is used, include "or equivalent" following the brand name or part number to demonstrate that use of another product is acceptable.

6.6 Include any special glassware cleaning instructions.

6.7 List special facilities required, such as a special room for handling hazardous materials.

7.0 Reagents and standards

This section lists and describes all reagents and standards required to perform the method, and provides preparation instructions and/or suggested suppliers as appropriate.

7.1 List the name of the reagent and the necessary purity, followed by any descriptive terms. List reagents in a logical order (e.g., by order of occurrence or use, by group). The method should require that reagents be ACS Reagent Grade unless otherwise specified.

7.2 Spell out the full name of inorganic reagents when first used, and include within parentheses the exact chemical formula, showing its water of crystallization, etc. Subsequently, refer to inorganic compounds by formula if they can be specified clearly in this way. As exceptions, always spell out the word "water" and the names of substances in their elemental state (e.g., "lead" not "Pb," "oxygen" not "O_2").

7.3 Spell out organic, organometallic, or complex inorganic compounds; chemical formulae are not necessary. Cite the CASRN to avoid ambiguity.

7.4 Avoid the use of trademarks and names of patented products. Use chemical names and common names, unless a specific product is required for a well-defined reason. The use of registered trade names is permitted.

7.5 Unique and unusual reagents can be named by brand. Whenever a brand name is used, include "or equivalent" following the brand name to demonstrate that another product can be used.

7.6 Specify the concentration of inorganic reagents in applicable terms, as follows:

Concentrated acids and bases	density
Dilute acids and bases	volume ratio, x + y (x volume of reagent added to y volume by water)
Nonstandardized solutions	normality, expressed decimally; or the equivalent of 1 mL of solution in terms of grams of a given element expressed as 1 mL = x.xx g of . . .

7.7 Specify filter paper by describing the significant characteristic such as porosity, rate of filtering ash content, etc., or by reference to ASTM Specification D1100 for *Filter Paper for Use in Chemical Analysis*.

8.0 Sample collection, preservation, and storage

This section provides requirements and instructions for collecting, preserving, and storing samples.

8.1 Give detailed directions for collecting, filtering (if applicable), preserving, shipping, and storing samples.

8.2 Use preservation procedures and holding times consistent with those specified in current EPA publications or regulations and with other methods for the same analytes.

9.0 Quality Control

This section cites the procedures and analyses required to fully document the quality of data generated by the method. The required components of the laboratory's quality assurance (QA) program and specific quality control (QC) analyses are described in this section. For each QC analysis, the complete analytical procedure, the frequency of required analyses, and interpretation of results are specified.

9.1 Include the following statements in the first subsection (Section 9.1): "Each laboratory that uses this method is required to operate a formal quality assurance program (Reference ___). The minimum requirements of this program consist of an initial demonstration of laboratory capability, ongoing analyses of standards and blanks as a test of continued performance, and [complete as appropriate to the method]. Laboratory performance is compared to established performance criteria to determine if the results of analyses meet the performance characteristics of the method."

"The analyst shall make an initial demonstration of the ability to generate acceptable accuracy and precision with this method. This ability is established as described in Section 9.2."

9.2 In Section 9.1, cite any options that the analyst is permitted, e.g., alternate extraction, concentration, or cleanup procedures; changes in columns or detectors. Specify that the analyst is required to repeat the required initial demonstration of laboratory capability each time a modification is made to the method. Include the following statements:
"Each time a modification is made to the method, the analyst is required to repeat the procedure in Section 9.2. If the change will affect the detection limit of the method, the laboratory is required to demonstrate that the MDL (40 CFR part 136, Appendix B) is lower than the MDL for that analyte in this method, or one-third the regulatory compliance level, whichever is higher. If the change will affect calibration, the analyst must recalibrate the instrument according to Section 10.";

"Changes that degrade method performance are not allowed. If an analytical technique other than the techniques specified in this method is used, that technique must have a specificity equal to or better than the specificity of the techniques in this method for the analytes of interest."; and

"The laboratory is required to maintain records of modifications made to this method. These records include the following, at a minimum:

- The names, titles, addresses, and telephone numbers of the analyst(s) who performed the analyses and modification, and of the quality control officer who witnessed and will verify the analyses and modification.
- A listing of analytes measured, by name and CASRN.
- A narrative stating reason(s) for the modification(s).
- Results from all QC tests comparing the modified method to this method, including:
  - (a) Calibration (Section 10)
  - (b) Calibration verification (Section 9.5)
  - (c) Initial precision and recovery (Section 9.2.2)
  - (d) Analysis of blanks (Section 9.4)
  - (e) Accuracy assessment (Section 9.3)
  - (f) Ongoing precision and recovery (Section 9.6)
- Data that will allow an independent reviewer to validate each determination by tracing the instrument output (weight or other signal) to the final result. These data are to include:
  - (a) Sample numbers and other identifiers
  - (b) Extraction dates
  - (c) Analysis dates and times
  - (d) Analysis sequence/run chronology
  - (e) Sample weight or volume
  - (f) Extract volume
  - (g) Make and model of analytical balance and weights traceable to NIST
  - (h) Copies of logbooks, printer tapes, and other recordings of raw data
  - (i) Data system outputs, and other data to link the raw data to the results reported"

9.3 In the remainder of Section 9.1, outline the QC requirements that will be described in the section, and the purpose for each type of QC (e.g., blanks, matrix spikes/matrix spike duplicates, calibration verification).

9.4 In Section 9.2, describe in detail the initial demonstration of laboratory capability.

9.5 Describe the procedure for matrix spikes, calculating percent recoveries, and calculating relative percent difference for duplicates.

9.6 Provide instructions for analysis of blanks, e.g., laboratory reagent blanks, method blanks.

9.7 Specify requirements for calibration verification.

9.8 Provide instructions for analysis of ongoing precision and recovery standards.

9.9 Include requirements for analysis of quality control samples (QCS).

9.10 Include the following statement at the end of Section 9.0: "Depending upon specific program requirements, field replicates and field spikes of the analytes of interest into samples may be required to assess the precision and accuracy of the sampling and sample transporting techniques."

10.0 Calibration and standardization

This section describes the method/instrument calibration and standardization process, and required calibration verification. Corrective actions are described for cases when performance specifications are not met.

10.1 Specify operating conditions or refer to manufacturer's recommended operating conditions. If appropriate, specify a precalibration routine as needed to document instrument stability.

10.2 Give detailed instructions for the use of standards to prepare calibration lines or tables. Include the number of calibration standards, the need for blanks, the frequency of calibration checks, the critical range, etc.

10.3 Give detailed instructions for internal standardization, including number and concentration of internal standards.

10.4 Include instructions for calibration data storage.

11.0 Procedure

This section describes the sample processing and instrumental analysis steps of the method, and provides detailed instructions to analysts.

11.1 For methods used for determination of a method-defined analyte, include the following statement in the introductory portion of Section 11.0 Procedure: "This method is entirely empirical. Acceptable results can be obtained only by strict adherence to all details." Do not include this statement in methods for which the analyte is a chemical or physical parameter, the characteristics of which are known (e.g., oil and grease, COD, BOD).

11.2 Include in proper sequence detailed directions for performing the analysis.

11.2.1 Include steps that are essential to the process and avoid unnecessarily restrictive instructions.

11.2.2 Organize the procedure by logical order of activity, e.g., sample preparation, extraction, analysis.

11.2.3 Describe the procedure in the imperative mood, present tense, e.g., "Heat the sample aliquot," rather than "The sample aliquot should be heated." Comments and descriptive information that are not in the imperative mood may be included, as appropriate.

11.2.4 Write the text so that it is concise and easily understandable.

11.2.5 When alternative procedures are given, state which is preferred.

11.3 In chemical methods, specify the size of sample aliquot and indicate the required measurement accuracy. (There is no need to weigh a sample to five significant figures in a spectrophotometric method where the final absorbance measurement yields data with only three significant figures).

11.4 Include "Notes" throughout the procedure to highlight critical points. Include notes of "WARNING" or "CAUTION" as appropriate to identify known or potential hazards to the analyst or the equipment, respectively.

11.5 Indicate steps in which timing is critical, e.g., if a determination may not be interrupted overnight. For a color reaction, indicate how long the color is stable.

12.0 Data analysis and calculations

This section provides instructions for analyzing data, and equations and definitions of constants used to calculate final sample analysis results.

12.1 Calculations—Provide directions for calculating the results of the analysis, including any equations.

12.1.1 Use the imperative mood, e.g., "Report results to three significant figures," rather than "Results should be reported to three significant figures."

12.1.2 Where there may be ambiguity of meaning, spell out names in the text (e.g., total Kjeldahl nitrogen) but use the abbreviations (e.g., TKN) in text where the meaning is clear, and in equations.

12.1.3 Define the symbols used in the equation immediately under the equation.

12.1.4 Use numerical values for any constants. Identify dilution factors, titration factors, etc.

12.2 Reporting results

12.2.1 Indicate the units in which the results are to be reported (e.g., µg/L, mg/kg).

12.2.2 If the sample is a solid material such as a sediment or sludge, indicate whether results are to be reported as wet weight or dry weight.

12.2.3 Specify the number of significant figures to be reported.

12.2.4 Require that all values obtained by various QC procedures are reported along with the calculated results of the analysis.

12.3 Interpretation of results—Use this heading in place of Calculations when the results of the analysis must be expressed in descriptive form, relative terms, or abstract values. List and define the descriptive terms or classifications used.

13.0 Method performance

This section provides method performance criteria for the method, including precision/bias statements regarding detection limits and source/limitations of data produced using the method.

13.1 Explain how the method was validated. Provide a detailed description of method performance, including data on precision, bias, detection limits (including the method by which they were determined and matrices to which they apply), and statistical procedures used to develop performance specifications.
Note: This information can be provided through reference to the method validation study.

13.2 At a minimum, state single-operator precision and accuracy on reagent water. If other sample types have been investigated, also provide this information for them.

13.3 If a collaborative study has been completed, describe the study and report the number of participating operators and laboratories, spike concentrations, level of replication, types of background waters, and any other significant aspects. If the study has been documented, cite the study report and include it in the References section. When citing reference documentation, the details of the study do not have to be included in this section.

14.0 Pollution prevention

This section describes aspects of the method that minimize or prevent pollution known to be or potentially attributable to the method.

14.1 Cite potential sources of pollution attributable to the method.

14.2 Recommend ways to minimize pollution.

15.0 Waste management

This section describes minimization and proper disposal of waste and samples.

15.1 Include the following statement as the first subsection: "It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required."

15.2 Provide instructions for sample and waste handling and disposal.

15.3 Include the following statement as the last subsection: "For further information on waste management, consult *The Waste Management Manual for Laboratory Personnel* and *Less is Better: Laboratory Chemical Management for Waste Reduction*, both available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th Street N.W., Washington DC, 20036."

16.0 References

This section lists references for source documents and publications that contain ancillary information.

Note: Each method should be a free-standing document, providing all information necessary for the method user to perform the method may be found. References within a method should be restricted to associated or source material. Procedural steps or instructions should not be referenced as being found elsewhere, but should be included in total within the method.

16.1 Include references for other, related EPA methods; and published studies/articles relating to method performance, techniques, or analytes, and health and safety.

16.2 List references in the order cited in the method, and assign each reference an identification number using Arabic numerals.

16.3 As a rule, do not list documents that are not readily accessible to the reader (e.g., unpublished theses, personal communications, private correspondence). If it is important to list these types of documents, identify where the reader may obtain a copy of the document.

17.0 Tables, diagrams, flowcharts, and validation data

This section contains all method tables and figures (diagrams and flowcharts), and may contain validation data referenced in the body of the method.

17.1 In addition to tables and figures, include additional useful information. Examples of such information include:

17.1.1 Notes on significance and interpretation of the method, used to amplify the statement in the text.

17.1.2 Development of equations used in the calculations.

17.1.3 Charts or supplementary information for computations.

18.0 Glossary

This optional section contains a glossary of terms, acronyms, abbreviations, and symbols used in the method.

Note: This information may appear in the Definitions section of the method (Section 3.0) or may be included in a glossary at the end of the method.

18.1 In the first subsection of the glossary, identify units of weight and measure used in the method and their abbreviations.

18.2 In the second subsection, define key terms and all acronyms used in the method.

18.2.1 List terms, acronyms, and abbreviations alphabetically.

18.2.2 Definitions should appear only once. Where an acronym or abbreviation represents a term that is defined under its full name, reference the full name as the definition for acronym or abbreviation.

APPENDIX F

CODE OF ETHICS

RI Analytical Laboratories, Inc. is committed to ensuring the integrity of its data and meeting the quality needs of its clients. We pledge to manage our business according to the following principles:

- To produce results that are technically sound and legally defensible;
- To assert competency only for work for which adequate equipment and personnel are available;
- To present services in a confidential, honest, and forthright manner;
- To have a clear understanding with the client as to the extent and kind of services to be rendered;
- To provide employees with guidelines and an understanding of the ethical and quality standards required in this industry;
- To operate facilities in a manner that protects the environment and the health and safety of employees and the public;
- To obey all pertinent federal, state, and local laws and regulations;
- To continually improve product and service quality;
- To treat employees equitably, acknowledge their scientific contributions, and provide them with opportunities for professional growth and development;
- To recognize and respond to community concerns; and
- To deal openly, honestly, and fairly in all business and financial matters with employees, clients and the public.

RI Analytical Laboratories, Inc.
Method SOP
Title – Total Organic Carbon in Liquids for Mid and Low Levels
EPA Method 415.1/SW-846 9060

Effective Date: March 27, 2003
Revision 002
Q.C. Coordinator _____ Date 03/27/03
Lab Manager _____ Date 3/28/03
V.P. Operations _____ Date 3/28/03

Title: Total Organic Carbon in Liquids for Mid and Low Levels

Method Detection Limit: 0.5 mg/l for Low level; 5 mg/l for Mid level

Scope and Application:
This method includes the measurement of organic carbon in drinking, surface and saline waters, domestic and industrial wastes.

Summary of Method:
The DC-80 Series is a modular TOC analysis system. Depending upon configuration, TOC can be measured by ultra-violet promoted persulfate oxidation or high temperature combustion, followed by infrared detection. External sparging is routinely used to remove inorganic carbon. Alternatively, inorganic carbon can be measured and subtracted from total carbon. The DC-80 series permits DIRECT (and also indirect by difference) measurement of Purgeable Organic Carbon. High sensitivity, combined with wide linear range, allows direct application to samples as diverse as ultra-pure water or heavily contaminated wastewater.

Definitions:
1. Labeled containers – Bottles that contain reagent made. They are labeled with the name of reagent made, Lot #s, date made, and tech's initials.

2. Expiration dates – Date reagent expires. Expiration dates are usually on the reagent bottles. If no expiration date is available, expiration date is one year after reagent is made or opened.

See Hawley's Condensed Chemical Dictionary, 12th Edition for terms that are not understood.

Interferences:
1. Carbonate and bicarbonate carbon represent an interference under the terms of this test and must by removed or accounted for in the final calculation.

2. This procedure is applicable only to homogeneous samples which can be injected into the apparatus reproducibly by means of a microliter-type syringe or pipet. The openings of the syringe or pipet limit the maximum size of particle which may be included in the sample.

3. Removal of carbonate and bicarbonate by acidification and purging with nitrogen, or other inert gas, can result in the loss of volatile organic substances.

Safety:

1. The toxicity or carcinogenicty of each analyte or reagent has not been precisely determined; however, each chemical should be treated as a potential health hazard. Personal exposure to any of these chemicals should be reduced to the lowest possible level.

2. This method does not address all safety issues associated with its use. RI Analytical Laboratories, Inc. provides OSHA Right to Know training on a yearly basis to address the potential safety issues for every method employed by the company, but not every contingency can be foreseen. MSDS files can be found in the lab managers office or with purchasing. Please use these sources as information if there any questions regarding the safety of any reagents, standards or equipment.

Equipment and Supplies:

1. Dohramann Total Organic Carbon, DC-80 automated analyzer
2. 15 ml graduated tubes with conical bottoms
3. 10 ml culture test tubes
4. Analytical balance, capable of measuring to 0.01 gram, calibrated daily
5. 10, 100, and 1000 ml volumetric flask, class A
6. 200 ul and 1000 ul unimetrics syringes
7. Test tube rack
8. Ultra pure DI
9. 2 ml volumetric pipette

Reagents and Standards:

1. Potassium Persulfate, $K_2S_2O_4$ – Commercially purchased.

2. Phosphoric Acid, H_3PO_4 – Commercially purchased.

3. Potassium Persulfate, 2 % solution w/v – Dissolve 20 grams of potassium persulfate and 1 ml of phosphoric acid in a 1000 volumetric flask, dilute with ultra pure DI. Transfer to a labeled container.

4. KHP – Potassium Hydrogen Phthalate – Commercially purchased. Dry in oven for at least 30 minutes before using.

5. KHP Standard – 2000 ppm Stock Solution w/v. Dissolve 0.425 gram of KHP and 0.100 ml of phosphoric acid into 100 ml volumetric flask. Transfer to a labeled container. This will be the LCS standard.

6. Alpha-trol – Commercially purchased. This will be the independent, secondary source standard.

7. Low Level Working Standard, 10 ppm – Using a syringe, measure 50 ul of the 2000 ppm stock standard into a 10 ml volumetric flask and diluted to mark with ultra pure DI. Transfer to a labeled container. Make up daily.

8. Mid Level Working Standard, 400 ppm Standard – Using a 2 ml volumetric pipette, pipette 2 mls of the 2000 ppm stock standard into a 10 ml volumetric flask and diluted to mark with ultra pure DI. Transfer to a labeled container. Make up daily.

Sample Handling and Preservation:

1. pH <2 with either H_2SO_4. Sampling and storage of samples in glass bottles is preferable.

2. Samples may hold up to 28 days at 4°C. In the laboratory, samples are stored in the walk-in refrigerator at 4°C (+/-2). Refrigerator is checked daily and the temperature recorded in the temperature logbook. If the temperature exceeds the specified limits and cannot be easily adjusted the supervisor is to be notified so that the situation can be quickly corrected.

Quality Control:

1. Batch blank run daily and for every 20 samples.
2. A LCS daily and for every 20 samples (% Recovery 80% - 120%).
3. Duplicate - Every 10 samples (%RD <20%).
4. Matrix Spike – Every 10 samples (% Recovery 80% - 120%).
5. A MS/MSD can be provided if requested and enough sample has been supplied by the customer.
6. CCV, Continuing Calibration Verification Standard – every 20 samples and at end of run. Needs to be from an independent or secondary source, (80-120%).

Calibration and Standardization:

1. Calibrate the analytical balance at 2 mg and 100 mg using class "S" weights. Calibration shall be within +/- 10% (i.e +/- 0.2 mg) at 2 mg and 0.5% (i.e +/- 5 mg) at 1000 mg. If values are not within these limits, recalibrate the balance.

2. At the initial start up "**CALIB**" light may or may not be illuminated. The calibration remains even if the power is turned off. The only way to un-calibrate is to press the "**CALIB**" button for more than one second. Even though the calibration factor in the memory is continuously maintained the same as calibrated, there are various reasons why the analyzer needs to be recalibrated from time to time. It is common to observe a change in calibration of 1% or 2% from one day to another. One of the main reasons for this change is a change in the gas flow rate, especially if the gas pressure is reduced overnight to save gas. When the gas pressure is brought back to 30 psi, it may not be exactly the same as the setting used on the previous day. Therefore, the calibration should be checked daily. A calibration check is preformed daily and if it is not within 10%, the analyzer is recalibrated.

A. To calibrate or recalibrate, press the "**CALIB**" button for more than one second to erase the previous calibration factor in the memory.

B. Inject the appropriate standard for the measurement range selected, either 200 ul or 1 ml of the Working Standard.

C. The analyzer will "beep" when ready. The reading should be within 10% of expected standard. If it is not, recalibrate following steps 2 A – C.

Instrumental Warm-Up Procedure:

1. Record in the TOC logbook, the analyst, date and time. Be sure to also include the lot numbers of the Alpha-trol.

2. Turn on the TOC analyzer. Turn on the gas, O_2, verify that the O_2 tank is above 500 psi, if it is not, than replace it with a new tank. The O_2 tank must be at 30 psi. Attach the system windings on the right side of the analyzer to the peristaltic pump. See Diagram 1. Remember that the green windings go to the waste and that the black windings go to the reagent, potassium persulfate. Turn white power switches "ON". Turn on the pump and the lamp "ON". **DO NOT** turn on the furnace switch for this procedure. Wait 30 minutes for the analyzer to warm up or until the base line stabilizes and the "Ready" button turns Green.

Mid-Level TOC Procedure:

1. For mid-level TOC samples, the 200 ul unimetric syringe will be used, turn the knob to 200 ul.

2. Using the 200 ul syringe, inject the Mid-Range Working Standard, the LCS into the injection port and press the "**START**" button.

3. The analyzer will "beep" when it has finished analyzing the sample. Verify that the sample is within the acceptable limits. If it is proceed to the next steps, if it is not, re-calibrate the analyzer by following step 2 A-C.

4. Inject 200 ul of ultra pure DI into the injection port and press the "**START**" button. This is the blank. Verify that the blank is less than the DL.

5. Inject 200 ul of the secondary source standard, the independent check standard into the injection port and press the "**START**" button. Verify that the standard is within acceptable limits, if it is not, it maybe necessary to re-inject the standard.

6. Line up samples on the bench top. Line up culture test tubes on the test tube rack. Label the culture test tubes with the sample ID. Shake sample well and pour some sample into the culture test tube.

7. Place the stainless steel sparger tube into the culture tube and sparge the sample for 10 minutes.

8. Take the sparger out of the test tube and rinse with DI.

9. Inject 200 ul of sample into the injection port and press the "**START**" button. When the analyzer "beeps", the sample is complete. Record the reading from the front display in the logbook. Please note: If the value is above the highest point on the curve, usually 400 ppm, a dilution is required.

10. Follow steps 7-9 for any additional samples.

11. Record any anomalies that may have occurred in the TOC logbook.

Low-level TOC Procedure:

1. For low level TOC samples, the 1000 ul unimetric syringe will be used, turn the knob to 1 ml.

2. Using the 1000 ul syringe, inject the Low-Range Working Standard, the LCS into the injection port and press the "**START**" button.

3. The analyzer will "beep" when it has finished analyzing the sample. Verify that the sample is within the acceptable limits. If it is proceed to the next steps, if it is not, re-calibrate the analyzer by following step 2 A-C.

4. Inject 1000 ul of ultra pure DI into the injection port and press the "**START**" button. This is the blank. Verify that the blank is less than the DL.

5. Inject 1000 ul of the secondary source standard, the independent check standard into the injection port and press the "**START**" button. Verify that the standard is within acceptable limits, if it is not, it maybe necessary to re-inject the standard.

6. Line up samples on the bench top. Line up culture test tubes on the test tube rack. Label the culture test tubes with the sample ID. Shake sample well and pour some sample into the culture test tube.

7. Place the stainless steel sparger tube into the culture tube and sparge the sample for 10 minutes.

8. Take the sparger out of the test tube and rinse with DI.

9. Inject 1000 ul of sample into the injection port and press the "**START**" button. When the analyzer "beeps", the sample is complete. Record the reading from the front display in the logbook. Please note: If the value is above the highest point on the curve, usually 10 ppm, a dilution is required.

10. Follow steps 7-9 for any additional samples.

11. Record any anomalies that may have occurred in the TOC logbook.

Shut down Procedure for TOC analyzer:

1. Release the windings on the right side of the analyzer and let lines run dry.

2. Turn off the power switches and the O_2 tank.

Troubleshooting:

1. See supervisor with any additional concerns or problems.

Calculations:

1. If the number ends with a 0 through 4 – round down; if the number ends with a 6 through 9 – round up.

   A. In reporting duplicates do not round the numbers in the calculations except for the end results.

2. To calculate the percent recovery (%REC) for the LCS:

$$\%REC = \frac{\text{concentration}_{(ug/L)}}{\text{spike added}_{(ug/L)}} \times 100$$

4. To calculate the percent recovery for the MS/MSD:

$$\%REC = \frac{\text{MS conc.}_{(ug/L)} - \text{sample conc.}_{(ug/L)}}{\text{spike added}_{(ug/L)}} \times 100$$

Method Performance:

1. A Laboratory Control Standard or a Continuing Calibration Verification standard is performed on a daily basis and every 20 samples to verify method. An independent check standard/secondary source standard is also preformed monthly to verify method.

2. A yearly Method Detection Limit (MDL) study, as prescribed in the 40 CFR 136, will determine proper detection limits for the given method analytes of interest and consecutively analyzing them on the instrument.

3. Sample detection limits may be mathematically altered due to sample volume, sample matrix, solubility, and other sample specific interferences. These mathematical changes are called Dilution Factors (DF) and are applied to the calculations involved in determining the final concentrations of analytes in the samples.

4. An Initial Demonstration of Proficiency is required of each analyst following the guidelines of SW-846 and the results kept on file.

5. Recoveries of matrix spiking compounds laboratory control samples and sample blanks are evaluated daily. These results are used to assess the overall fitness and changes of the instrument over time and are an important tool for determining when general maintenance may be required. See section data assessment and Acceptance Limits.

Pollution Prevention:

1. Standards should be prepared in volumes consistent with laboratory use to minimize the volume of expired standards to be disposed.

2. If during the course of performing this test method, aspects can be changed to reduce waste either in volume or in concentration, please contact a supervisor the Q.C. Coordinator to suggest methods to reduce waste.

Data assessment and acceptance for criteria for quality control measures:
The LCS must be within 80-120 % recovery, the Duplicate must have a % RD of <20% and the Spike must have a % recovery of 80-120%. If these conditions are not met, the LCS, Duplicate and Spike and/or sample must be rerun. If the spike still does not fall within these limits, it maybe due to sample matrix, spike another sample.

Corrective Actions For Out-of-Control Data

1. If out-of-control data is obtained during the course of this method, corrective actions must be taken. This should take the form of checking the reagents, the instrument, or calculations. If those actions do not identify the problem, contact a supervisor or qualified person for guidance.

2. For out-of-control data, or unacceptable data, notify the immediate supervisor who should then consult with the Q.C. Coordinator and/or the V.P./Operations for guidance. Resolution of the discrepancy or problem is accomplished with a written case narrative attached to the final report and customer consultation.

3. A Non-Conformance report must be filled and given to the Q.C Coordinator.

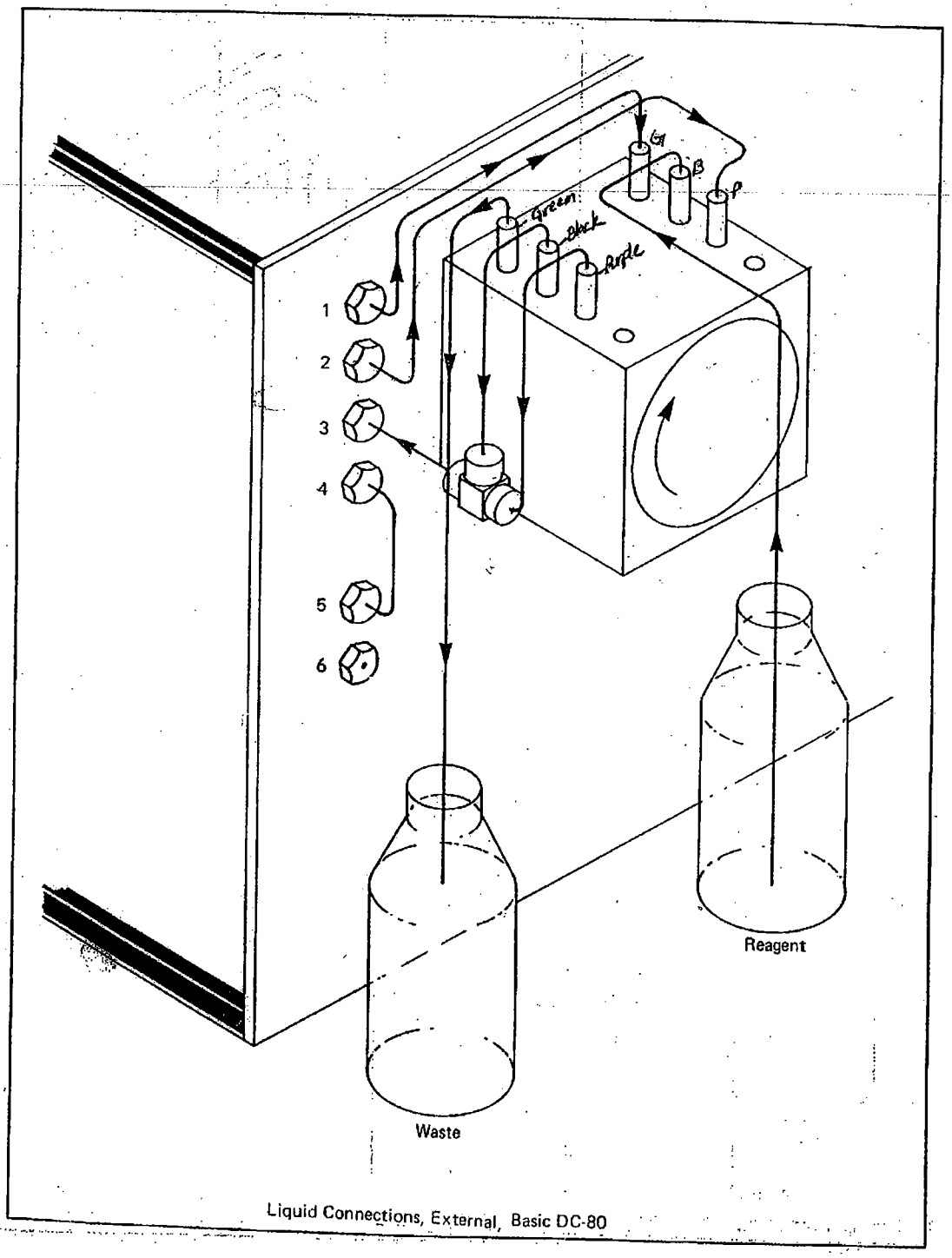
Waste Management:
The See "Waste Management SOP" located on the bookshelf outside Log-In or "Administrative SOP Proper Waste Disposal" located in the QC Coordinator's office.

References:

1. EPA Method 415.1 - 600/4- 79-020
2. EPA SW-846 Method 9060 A

RI Analytical Laboratories, Inc.
Method SOP
Title – Total Organic Carbon in Liquids for Mid and Low Levels
EPA Method 415.1/SW-846 9060

Tables, Diagrams, Flowcharts, and Validation Data:



Liquid Connections, External, Basic DC-80