Seven Mile Creek CWP Project
Quality Assurance Project Plan

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Table 1. DISTRIBUTION LIST

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In addition, copies of the QAPP will be made available to all samplers and other field personnel, other involved county staff, and other interested parties.

INTRODUCTION

The Seven Mile Creek Watershed (SMCW) project is a collaborative effort to help protect and enhance the water quality of Seven Mile Creek. Seven Mile Creek is one of Nicollet County's most visible natural resource with a 630-acre county park located at the mouth of the watershed. The park and designated trout stream is used by thousands of visitors each year. Ongoing efforts in the late 1980s to help protect the drinking water for the city of St. Peter sparked local interest to investigate the water quality of unique streams like Seven Mile Creek. The watershed project has turned into one of the most showcased and studied watersheds in the Middle Minnesota Major River Basin. Additional information about the watershed project may be found at http://mrbdc.mnsu.edu/org/bnc/.

With that perspective, grants acquired from the Department of Natural Resources Environmental Partnerships and Minnesota Pollution Control Agency Resource Investigation programs were used to study the watershed in the mid-1990s. Also, in the mid-1990's three monitoring stations were established and efforts to provide education about water quality protection began. A report summarizing the water quality of the watershed was printed in 2001. The report is available at http://mrbdc.mnsu.edu/reports/midminn/sevenmile.html. According to the diagnostic study, fecal coliform bacteria, high nutrient loadings from phosphorus and nitrates, and extreme peak flows resulting in accelerated stream bank erosion were found to be the largest water quality impairments in the watershed. Soon after, watershed coalition efforts materialized into a Clean Water Partnership. The Clean Water Partnership[1] program for Minnesota was created in 1987 to address pollution associated with runoff from agricultural and urban areas. The program provides local governments with resources to protect and improve lakes, streams, and ground water.

SECTION 1: PROJECT DESCRIPTION

In 2002, work began to accelerate the voluntary adoption of Best Management Practices (BMPs).

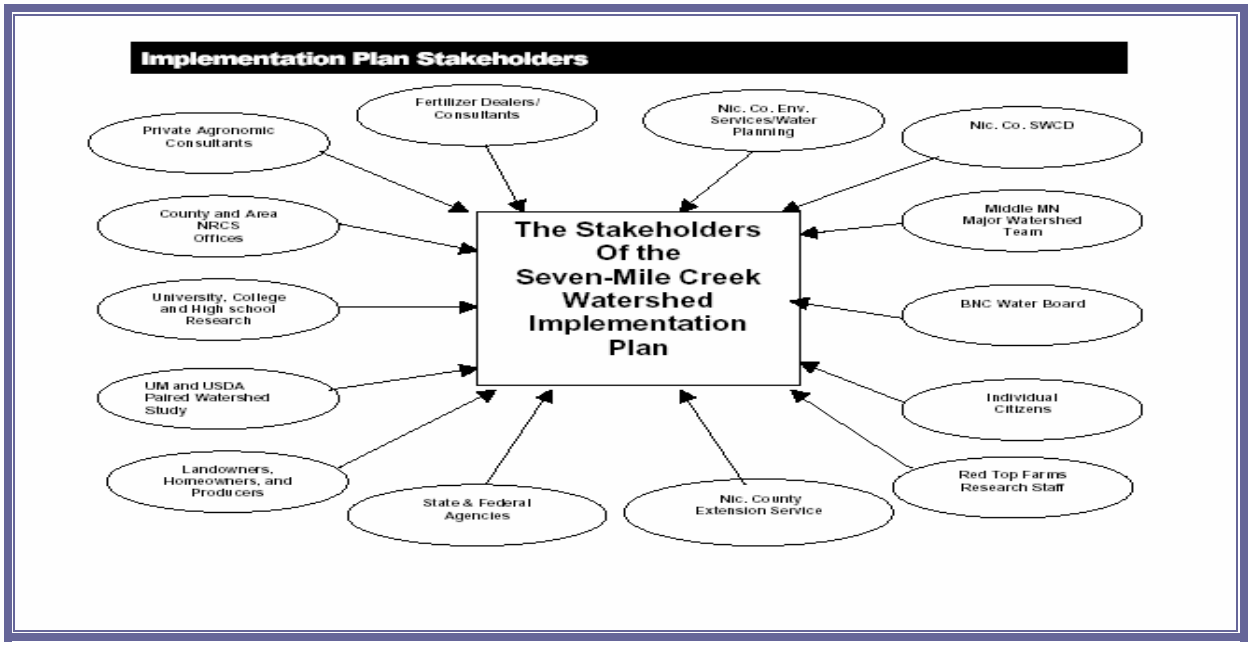
[1] The Seven Mile Creek CWP formed in 2002.

The three-year CWP project (2002-2005) focuses on accelerating conservation practices by providing additional technical and financial assistance to watershed landowners and producers. The project focuses on education, nutrient management, septic system upgrades, filter strips, wetlands, water storage, stream trout habitat creation, and stream bank erosion control using soil bioengineering techniques. Intensive water quality monitoring and watershed assessments have continued throughout the project.

COOPERATORS

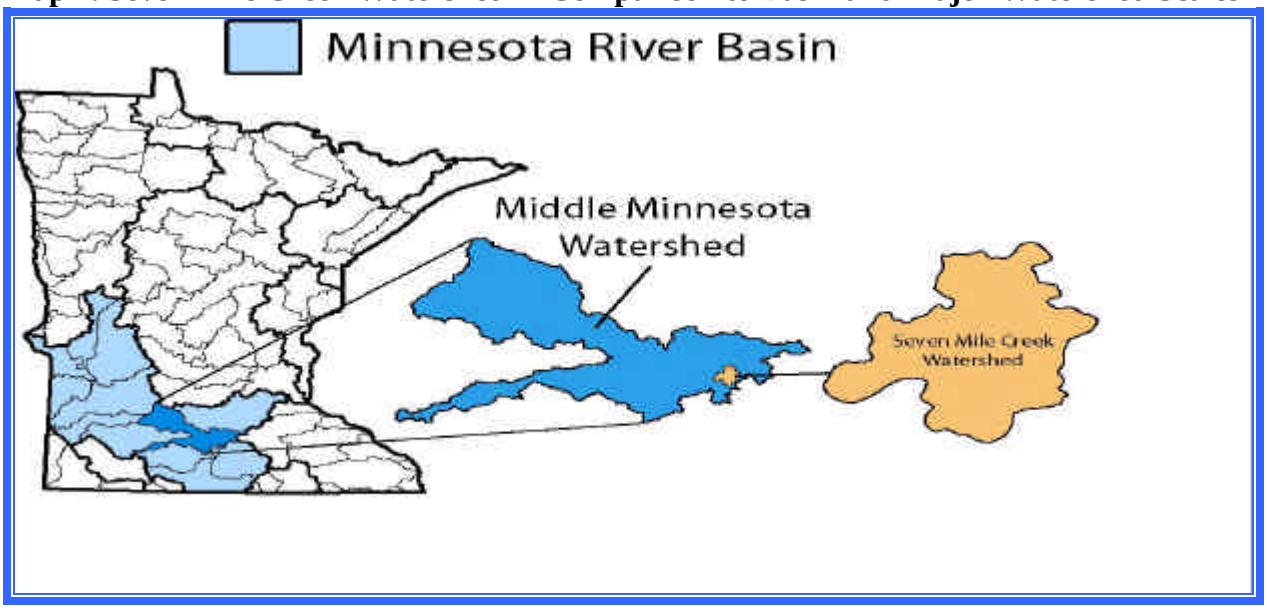
The Seven Mile Creek Watershed Project is a mutual effort by watershed farmers, landowners, citizens, and county, state, and federal groups. The coalition interested in improving this watershed includes traditional water resource agencies: Brown Nicollet Environmental Health, Soil and Water Conservation District (SWCD), Natural Resource Conservation District (NRCS), Environmental Services, Farm Service Agency (FSA), Minnesota Department of Agriculture (MDA), Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (MDNR) as well as two branches of the University of Minnesota - Soils/Agriculture and Public Health, the Center for Agricultural Partnerships, Blue Earth Consulting, agri-business retailers, U.S. Department of Agriculture (USDA) paired watershed study, and the McKnight Foundation. In addition, the watershed also has a 3,000-head Northern Plains Dairy operation which will begin operations in 2003, and Red Top Farm, southern Minnesota's long-running demonstration farm. Both are valued partners in the watershed protection project. At the time of this study, the Brown-Nicollet-Cottonwood Water Quality Board is the project sponsor and coordinator. Over 15 agencies, citizens groups, and private enterprises are involved in this watershed project.

Chart 1. The Seven Mile Creek Watershed Implementation Plan Stakeholders



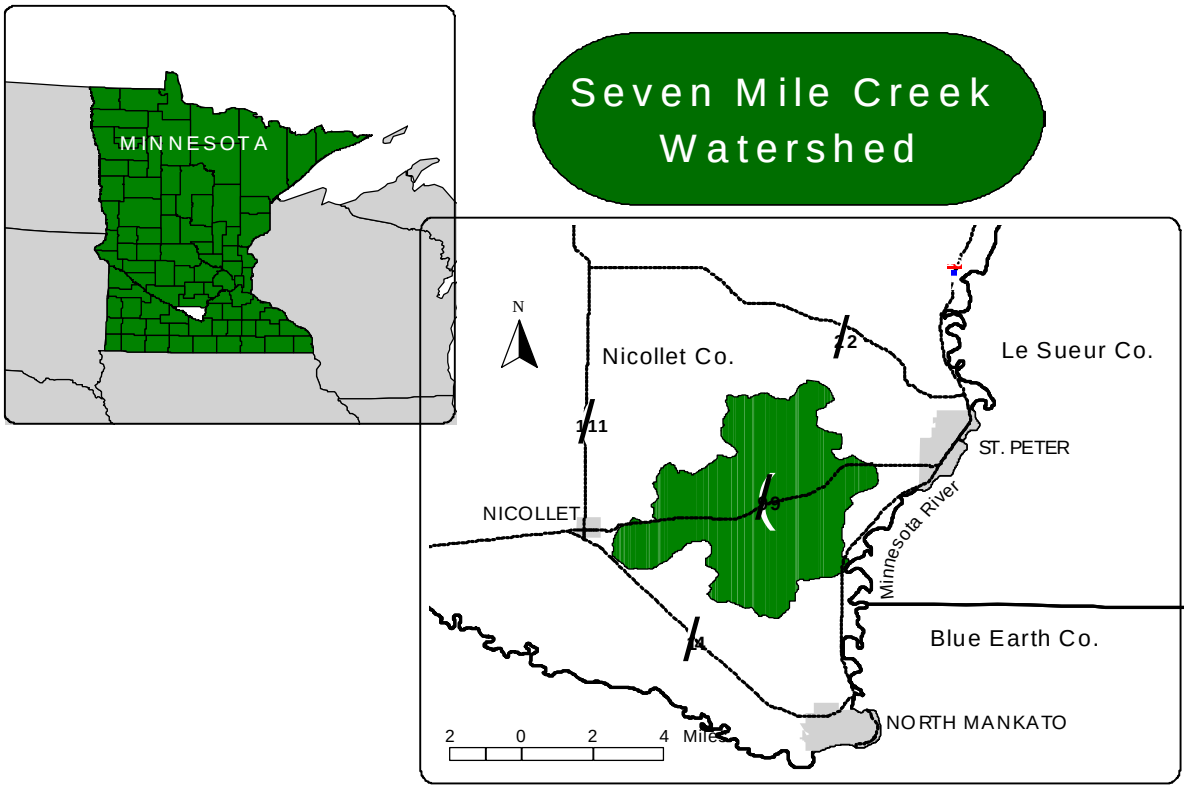
Map 1 shows the relationship of Seven Mile Creek to the Minnesota River Basin and the Middle Minnesota Major Watershed. Map 2 and 3 are more detailed maps of Seven Mile Creek Watershed. Except for the Little Cottonwood River, the streams comprising the Middle Minnesota Basin are first- or second-order streams. That makes this basin somewhat unique; the rest of the twelve basins all have identifying dendritic rivers. The Middle also differs from all the other basins in that there is no single reach on the main river where the effects of the basin drainage can be monitored. This is because the mouths of four entire basins (Cottonwood, Blue Earth, Watonwan, and Le Sueur) enter the Minnesota at points in the area of the Middle Minnesota. Due to the large number of small streams feeding the Minnesota River, this can pose difficulty in establishing water resource monitoring and implementation plans for the Middle Minnesota Major Watershed. This project does not include work on two streams, which are already under assessment by separate Clean Water Partnerships--the Little Cottonwood River Project (see *Little Cottonwood River Restoration Project*, 2000 for more information on that particular watershed) and the Lake Crystal-Minneopa Creek Project. The Major Middle Minnesota streams on the south and east sides of the Minnesota are: Wabasha Creek, Hindeman Creek (also known as Spring Creek), the Little Cottonwood River, Minneopa Creek, and Shanhaska Creek.

Map 1. Seven Mile Creek Watershed in Comparison to Basin and Major Watershed Scales



Watershed Information – The Middle Minnesota Basin covers 1,350 square miles in parts of eight counties in south central Minnesota--Redwood, Brown, Cottonwood, Blue Earth, and Le Sueur on the south and east side of the Minnesota River, and Renville, Nicollet, and Sibley on the north side. The basin ranks sixth in area of the twelve watersheds supplying the Minnesota River.

Map 2. The Seven Mile Creek Watershed



Project Objectives - The Minnesota River does not meet state and federal water quality standards and is a major source of pollution to the Mississippi River. It is a high priority of the State of Minnesota to restore the Minnesota River to fishable and swimmable conditions within ten years, from 1992-2002. The Minnesota River Assessment Project (MRAP) recommendations translate this general goal into specific pollutant reduction targets and suggest changes required to achieve the targets.

Recommendations include:

· Forty percent reduction in total suspended solids
· Maintenance of nitrate concentrations at less than ten parts per million
· Development of a phosphorus standard for the basin
· The implementation of sediment-reduction and cropland soil loss programs
· Removal of bacteria and other pathogens, which make the river unsafe for human contact

Project Site – As part of the water quality study for the Seven Mile Creek Watershed sediment and nutrient loadings were calculated at two tributaries (county drainage ditch 13 and 46a) and the main stem of the creek. In addition, fecal bacteria, dissolved oxygen, transparency tube readings, pH, conductivity, and temperature levels were studied. The information derived from water quality monitoring will:

- Help identify areas within the watershed that are contributing more or less of a particular pollutant of concern and therefore increase the efficiency of implementing sparse cost share dollars for remediation purposes.
- Allow water resource managers to rank Seven Mile Creek Watershed with other similar watersheds with the Middle MN River Basin in an effort to prioritize funding and clean up efforts.
- Help determine realistic Total Maximum Daily Load (TMDL) and water quality goals needed to meet local, state, and federal standards. Three water quality monitoring sites were established within Seven Mile Creek Watershed. The three sites were selected based on spatial proximity to areas of environmental concern, feasibility of determining stream discharge relationships, and previous monitoring history. The three sites are characterized as Hwy 99, Cty. Rd. 13, and mouth
- Monitoring sites are labeled as sites 1, 2, 3, respectively. The locations of all water quality sampling sites are shown graphically on map 3, chapter 1 with respected subsheds. Detailed site descriptions can be found in section A of the appendix. Photos 5-7 at the end of this chapter are also included to portray the overall setting of monitoring sites as well as some of the equipment used in the study.

Basis for Site Selection

- Spatial proximity to capture entire minor shed
- Proximity to road or culvert
- Previous water quality study location
- Rating curve development feasibility

Site 1 is located downstream of State Highway 99 West of St. Peter near county ditch 13. Stage at site 1 is measured by a stilling well. A Campbell Scientific CR-500 records the changes in water level sent from a potentiometer housed in a wooden box atop of the stilling well. All of the equipment was installed in March of 2000. A staff gage was installed on the cement culvert as well.

Downstream of State Highway 99. Samples taken near Box culvert. Stream Flow taken upstream in ditch about 100 yards. Nicollet County, Oshawa Twp, T110, R27 Sec 23, NE1/4, SW1/4

Site 2 is located downstream of County RD 13 near county ditch 46. The site contains a similar monitoring system to site 1. The only difference is that a Texas Instruments tipping bucket is installed to measure rainfall.

Downstream of Cty. Rd. 13. Stream flow taken just inside of box culvert on downstream side. Nicollet County, Oshawa Twp, T110, R27 Sec 23, SE1/4, SW1/4

Site 3 is located in Seven Mile Creek County Park near the mouth of the watershed (near first foot bridge). A staff gage, and CR-10 data logger were installed to determine stage. A Texas Instruments tipping bucket rain gage was in operation at this site from 2000. An INW pressure transducer measures stage at this location.

Mouth site, upstream of first footbridge in County Park. Stream flows taken upstream of bridge about 50 yards. Nicollet County, Belgrade Twp, T109, R27 Sec 12, NW1/4, SW1/4

Project Schedule - Samples were collected at all three sites during monthly scheduled times from March through October in 2000. All loading rates and other calculations are based on the growing season of April 1 through September 30 (roughly 180 days). In addition, water samples were collected over a range of river discharge conditions to characterize the change in water quality as the creek responded to both dry and wet conditions. Additional samples were taken at all three sites during low flow (base flow conditions) to assess the influence of point sources of pollution such as septics. Conversely, samples were also taken during high flow to document the effects of non-point source pollution from storm water runoff. Strict attention was made during the monitoring season to gather a wide spectrum of climatic/flow conditions to insure the best possible representation of the water quality in the watershed at the time of the study.

Sampling for water quality parameters and flows under climatic conditions included:

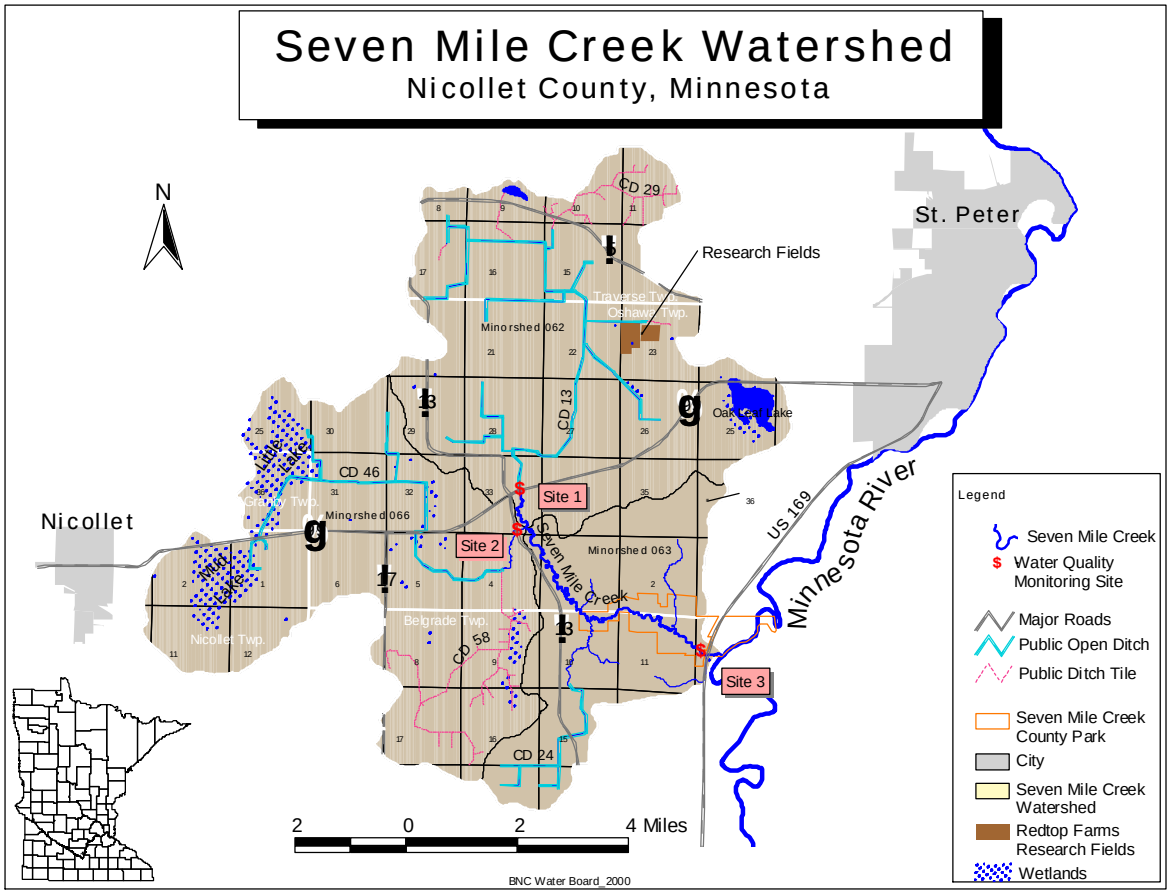
- Early Spring (first storm after snow melt)
- Emergent Crop Period Storm
- High Evapo-transpiration (ET) - Low Flow (late July or early August)
- Post ET (fall)
- Low Flow (late fall)

In general, all three sites are sampled from early April through September. In 2000, a total of 15 grab samples were taken. In 2001 a total of 16 grab samples were taken with two additional taken from automatic samplers.

Water samples are sampled and analyzed according to methods adopted by the USGS MPCA, and US Environmental Protection Agency protocol. Collection of all grab samples followed protocols established by the Environmental Protection Agency. Samples are field-tested using portable meters for pH, Temperature, Specific Conductance, Dissolved Oxygen and Transparency. Field meters were calibrated each day before use. Samples are analyzed by the state-certified Brown Nicollet Environmental Health Laboratory in St. Peter, Minnesota for the following parameters: Total Suspended Solids, Total Phosphorus, Ortho-Phosphorus, Nitrate-Nitrogen, Fecal Coliform bacteria, and Total Coliform bacteria. Reporting units and methods are shown in table 14.

Only approved laboratory and field methodology was used in the capture of water quality data. Clear and accurate data was the continuous objective. In the event that errors did occur, they were identified and corrected. Spikes, duplicates and blanks are run every ten samples. Both field and laboratory staff were readily able to identify outliers. When these emerged, re-sampling was performed as soon as possible, instruments were checked, and/or unusual circumstances (such as rainfall dilution or contamination by a point source) were identified and annotated.

Map 3. Detailed Map of The Seven Mile Creek Watershed



Factors that may affect the sampling schedule include planned storm event sampling in that the occurrence of storms can't be predicted. Equipment malfunction may also affect the sampling schedule in that an additional unscheduled sampling trip will be required to compensate for the unobtained data.

Table 2. Milestone Schedule for 2004

	April	May	June	July	August	September	October
Staff Training	?	?	?				
Monitoring	?	?	?	?	?	?	
Data Analysis		?	?	?	?	?	
Data Report							?

Table 3. Parameters, Analytical Methods, and Reporting Units

Table 14

Reporting Units and Method

Constituent or physical Property	Reporting Unit	Laboratory Method
Bacteria, fecal coliform, membrane filter	Col/100ml	Membrane filter
Bacteria, fecal streptococci, membrane filter	Col/100ml	Membrane filter
Bacteria, total coliform, membrane filter	Col/100ml	Membrane filter
Discharge	ft^3/sec	Velocity meter
Dissolved oxygen (DO)	mg/L	Membrane electrode
Nitrogen, as No3-N	mg/l	Electrode or Hach Spectrophoto meter
pH	Units	Electrometric
Phosphorus, dissolved ortho as P	mg/L	Hach manual digestion with automated color development
Phosphorus, total as P	mg/L	Hach manual digestion with automated color development
Sediment, suspended, concentration (TSS)	mg/L	Filtration and membrane
Specific Conductance	micromhos/cm	Wheatstone-Bridge meter
Transparency (tube)	Cm	
Water Temperature	°C	

SECTION 2: PROJECT ORGANIZATION AND RESPONSIBILITY

Table 4. Key Personnel and Project Responsibilities

Name	Project Title/Responsibility
Kevin Kuehner	Project Coordinator / Project Primary Oversight
Scott MacLean	Water Quality Technician / Monitoring
Lee Ganske	Project Manager / Data Review and Validation
Marcy Pengilly	Accountant / Fiscal Management
Pat Baskfield	Hydrologist/ Flow Measurement

SECTION 3: DATA QUALITY OBJECTIVES (DQOs)

Virtually all environmental data are only approximations of the true values of the parameters measured. These estimates are affected by the variability of the medium being sampled and by random and systematic errors introduced during the sampling and analytical procedures.

DQOs are qualitative or quantitative statements of:

- Precision (a measure of random error)
- Bias (a measure of systematic error)
- Representativeness
- Completeness, and
- Comparability

Sampling and/or analytical precision may be determined from split or duplicate samples by calculating the Relative Percent Difference (RPD) as follows:

$$\mathbf{RPD = (A - B) \div ((A + B) / 2) \times 100}$$

where A is the larger of the two duplicate sample values and B is the smaller value.
Where three or more replicate samples or measurements have been taken, calculate the Relative Standard Deviation (RSD) instead of the RPD as follows:

$$\mathbf{RSD = (s/?) \times 100}$$

Where **s** is the *standard deviation* and **?** is the *mean* of the replicate values.

Precision:

Table 5. Required Precision of Duplicate Samples

Analytical Parameter	Required Precision
Fecal and Total Coliforms	30% RPD
Total Suspended Solids	30% RPD
Nitrate - Nitrogen	10% RPD
Total Phosphorus	30% RPD
Orthophosphorus	30% RPD
pH*	0.3 Units
Temperature*	0.3°C
Specific Conductance*	10% RPD
Dissolved Oxygen*	0.1 mg/L
Transparency*	N/A

*Field Measurement

Bias:

Field bias will be determined by taking a sampler blank if a sampling device is used. No sampler blank will be taken if all samples are taken by use of grab sampling. All sample bottles are pre-cleaned, disposable, and will not be rinsed with sample water prior to grab sampling. Sampler blanks will comprise 10% of all samples taken when using a sampling device. In addition to occurring in the field, bias can also occur in the laboratory. The laboratory Quality Assurance Manual (QAM) specifies the steps taken to minimize bias in the laboratory. A laboratory QAM and Standard Operating Procedures (SOPs) are on file at the MPCA. The laboratory QAM and SOPs have been reviewed by the MPCA WQ QAC and found to contain QA/QC measures to ensure the production of quality data.

Completeness – Expressed as the number of valid (usable) data points made to the total number of measurements made. Percent completeness is determined separately for each parameter and is calculated as follows:

% Completeness = (number of usable data points ÷ number of planned data points) x 100

Situations that may prevent the acquisition of the total number of samples specified in the sample design include:

- Stream flooding that prevents the sampletaker from reaching the sample station
- Unavailability of a sampletaker due to illness or other reason
- Errors in sampletaking resulting in insufficient sample quantities to perform all parameters of the sampling design
- Failure to use or inappropriate use of preservative that may compromise the sample
- Exceedence of holding times
- Failure to properly label and identify the samples

Measures that may be used to compensate for loss of data:

- Follow-up compensatory sampling when sample dates are missed
- Flagging data rather than declining to include them in the data set
- Laboratory reanalysis of samples that are correctly taken, arrive at the laboratory in good condition, yet give values that are greatly different than those expected.
- Laboratory reanalysis of duplicate samples that vary by more than twice the maximum RPD specified under ‘Precision’, above
- Resampling when sampler blank analysis indicates significant carryover contamination between consecutive samples

Representativeness:

Representativeness will be maximized by use of proper sampling design, following the sampling plan, use of proper sampling protocols, observance of holding times, proper use of sample preservatives, and keeping samples cooled to 4° C.

Comparability:

Comparability will be maximized by using the same laboratory throughout this project, establishing the same QA objectives for each year of the project, and by ensuring that the same field equipment and sampling protocols are used throughout the duration of the project. Use of the same laboratory throughout the project will help ensure reproducible laboratory sample handling and analysis.

Table 6. Expected Ranges of Data Results

Analytical Parameter	Range
Fecal and Total Coliforms	4 – 50,000 cfu/100 mL
Total Suspended Solids	5 – 70 mg/L
Nitrate - Nitrogen	0.5 – 15 mg/L
Total Phosphorus	0.04 – 0.8 mg/L
Orthophosphorus	0.04 – 0.6 mg/L
pH*	6.0 – 8.0 pH Units
Temperature*	0° - 35°C
Specific Conductance*	-
Dissolved Oxygen*	3 - 15 mg/L
Transparency*	N/A

*Field measurement

Failure to meet all these quality objectives may affect the decision making process by:

- Causing decisions to be made based upon data obtained from fewer samples than specified by the sample design
- Causing the decision to delist the reaches whereas they actually remain impaired
- Causing the decision to continue to list the reaches whereas they actually are no longer impaired
- Causing decisions to be made based upon samples that do not truly reflect the condition of the reaches
- Causing inconclusive decisions due to excessive variability between duplicate samples

SECTION 4: SAMPLING PROCEDURES

Sampling sites are described in Section 1, Project Description.

Table 7. Parameters, Holding Times, Containers, and Preservatives

Laboratory Analytical Parameter	Holding Time	Container and Preservative*
Fecal and Total Coliform	24 H**	1 L plastic; Ascorbic acid
Total Suspended Solids	7 D	1 L plastic; None
Nitrate - Nitrogen	2 D	250 mL plastic; H_2SO_4 to pH < 2
Total Phosphorus	28 D	250 mL plastic; H_2SO_4 to pH < 2
Orthophosphorus	2 D	1 L plastic; None
pH†	Immediately	N/A
Temperature	Immediately	N/A

Specific Conductance†	28 D	N/A
Dissolved Oxygen†	Immediately	N/A
Transparency†	N/A	N/A

*All samples cooled to 4° C.; **6 Hours if used for enforcement purposes; †Field Measurements

Field equipment to be used:

- Dissolved Oxygen Meter
- Transparency Tube
- pH Meter
- Conductivity Meter
- Thermometer

Cleaning methods for the Dissolved Oxygen Meter, pH Meter, and Conductivity Meter may be found in Appendix A.

Reagents, supplies, and spare parts needed for field work:

- Spare membranes and filling solution for the Dissolved Oxygen Meter
- A Winkler Kit for calibrating the Dissolved Oxygen Meter
- Distilled water
- Vials of 10% sulfuric acid (H_2SO_4) supplied by the laboratory
- Squirt bottle with deionized water
- Ice
- Insulated coolers
- Extra sample bottles
- Plastic sampler bottle with extension pole
- Spare batteries for meters
- Permanent markers, pens, pencils
- Field sheets
- Lab sheets
- Field notebooks
- Clipboard
- Compass
- Area maps
- Labels
- Gloves, latex and cloth
- Tool box and assortment of tools
- Cellular phone
- Duct tape
- Length of rope
- Camera and film
- Rain gear
- Change of clothes
- Sunglasses and hat
- Sun screen
- Insect repellent
- First aid kit
- Flotation device
- Survival kit
- Safety boots
- Safety glasses
- Material Safety Data Sheets (MSDSs) for reagents and preservatives used

None of the samples taken for this project will be investigative samples in the sense that investigative samples are typically taken in response to a spill, illegal dumping, or other event that would cause an adverse condition to occur in one or more of the reaches such as a fish kill, algae bloom, or the observance of unusual odors or colors in the waters of the reaches.

Ten percent (10%) of all samples taken, both field measurement and laboratory analysis, will be QC samples, both sample duplicates and sampler blanks. Duplicates and blanks submitted for laboratory analysis will be labeled as such.

Information on parameters to be sampled may be found in Table 8.

The sample matrix for all samples will be ambient stream surface water.

The sampling schedule may be found in Table 2.

Information on sampling methods may be found in Appendices B, D, F, and G.

Information on Stage Monitoring may be found in Appendix C.

Information on sample containers to be used and sample holding times may be found in Table 7.

SECTION 5: CUSTODY PROCEDURES

Sample containers are labeled with the date of sample, military time of sample, parameter(s) to be analyzed, and preservative used, if any.

Immediately following sampling, each sample bottle is placed on ice in an insulted cooler. When sampling is complete the cooler is sealed and labeled with the name and address of the receiving laboratory. The laboratory is notified in advance of the anticipated date of sample arrival at the laboratory. The samples are hand-delivered to MVTL Laboratories within 4 hours of completion of sampling.

SECTION 6: CALIBRATION PROCEDURES AND FREQUENCY

Field instruments to be used include a Transparency Tube, a pH Meter, Dissolved Oxygen Meter, a Specific Conductance Meter, and a Thermometer. There is no calibration requirement for the Transparency Tube however cleaning before each use is required. The Meters will be calibrated before each sampling event immediately before going out into the field. A second calibrated Dissolved Oxygen Meter will be used to verify the accuracy of the Dissolved Oxygen Meter to be used. If a second Dissolved Oxygen Meter is unavailable, the Dissolved Oxygen Meter to be used will be calibrated with a Winkler Titration Kit.

Laboratory calibration procedures and frequencies for instruments to be used to analyze samples taken for this project are available as part of the laboratory QAM and SOPs which are on file at the MPCA.

SECTION 7: ANALYTICAL PROCEDURES

The field instruments and laboratory analytical methods including reporting limits have been reviewed and are of sufficient sensitivity to meet the DQOs for this project.

The parameters to be analyzed in the laboratory and the approved analytical methods to be used are as follows:

Table 8. Parameters and Analytical Methods

Analytical Parameter	Analytical Method
Fecal and Total Coliforms	SM* 9222 D
Total Suspended Solids	SM 2540 D
Nitrate - Nitrogen	SM 4500-NO_3^-
Total Phosphorus	SM 4500-P F
Orthophosphorus	SM 4500-P E
pH	SM 4500 H
Temperature	-
Specific Conductance	SM 2510 B
Dissolved Oxygen	SM 4500-D
Transparency	-

*Standard Methods for the Examination of Water and Wastewater, 20th Edition, 1998.

SECTION 8: QUALITY CONTROL PROCEDURES

Field duplicate samples will comprise ten percent (10%) of samples taken for laboratory analysis. Field blank samples will comprise ten percent (10%) of samples taken through use of a sampling device. The limits of acceptability of field duplicate samples are given in Table 6. Field blank samples should be free of analytes at levels at or above the respective laboratory method reporting limits. Field duplicate samples that do not meet the limits of acceptability as specified in Table 6 will be flagged and designated as estimated. Field blank samples that contain analyte concentrations at or above the corresponding laboratory method reporting limit will be flagged and designated as estimated.

SECTION 9: DATA REDUCTION, REVIEW AND REPORTING

Data Reduction:

Field measurements will be reported as recorded in the field notebook.

Data generated through laboratory analysis will undergo data reduction by the laboratory QA Officer prior to the reporting of the final results. If laboratory analytical results of duplicates gives a RPD > 25%, the samples will be reanalyzed. If reanalysis gives the same result data will be qualified as being estimated. If laboratory analytical results of sampler blanks indicate the presence of one or more analytes at > ½ the respective analyte reporting limit, the samples will be reanalyzed. If reanalysis gives the same result data will be qualified as being estimated.

Data Review:

The Project Leader will compare the data in the field notebooks and laboratory reports with the data in the draft final report to ensure accuracy. S/he will also review notes in the field notebook

to determine if any problems or unusual events occurred that may justify flagging or disqualifying the data.

The formal data set will be reviewed by the MPCA Project Manager for errors, omissions, qualified data, and flagged data. S/he will also determine the Relative Standard Deviation (RSD) of all the data points for each parameter according to the following equation:

RSD = (s/?) x 100

Where **s** is the *standard deviation* of all the data points for the parameter and **?** is the *mean* of the data points.

Reporting:

Laboratory analytical reports will be made available to the Project Leader and to the MPCA Project Manager in .pdf electronic format and, at the request of the Project Leader, also in hard-copy format. The final approved data report will be delivered by the Project Leader to the MPCA Project Manager electronically and in hard-copy in .xls spreadsheet format with hard-copy laboratory analytical reports attached.

SECTION 10: PERFORMANCE AND SYSTEMS AUDITS

An audit serves to verify that QA, QC, SOPs and other procedures are being followed as specified in the Project QAPP. It also is used to detect potential problems so corrective actions may be implemented. The number of audits performed and their detail is determined by the duration and scope of the project. Describe the audit of field procedures used for the project including sampling, sample handling, and instrument maintenance. Laboratories conduct routine audits of their sample handling, sample analysis, instrumentation, staff analytical performance, and instrument maintenance. This information is available from the laboratory upon request.

The analytical laboratory conduct routine audits of its sample handling, sample analysis, instrumentation, staff analytical performance, and instrument maintenance as specified in its QAM and SOPs.

An audit of the project field procedures, sampling methods, sample handling, and instrument maintenance will be performed by the MPCA WQ AC on a time available basis.

Table 9. Reporting Limits

Analytical Parameter	Reporting Limit
Fecal Coliform	4 cfu/100 mL
Total Suspended Solids	1.0 mg/L
Nitrate - Nitrogen	0.05 mg/L
Total Phosphorus	0.003 mg/L
Orthophosphorus	0.005 mg/L
pH*	-
Temperature*	-
Specific Conductance*	0.2 Siemens/cm

Transparency*	1 cm
Dissolved Oxygen*	0.1 mg/L

*Field Measurement

SECTION 11: PREVENTIVE MAINTENANCE

Meters will be thoroughly cleaned following each use and inspected monthly for unusual wear.

The analytical laboratory conducts routine preventive maintenance on its analytical equipment as specified in its QAM and SOPs.

SECTION 12: DATA QUALITY ASSESSMENT

Field and laboratory data will be assessed by the Project Leader and MPCA Project Manager as they become available to determine if the sampling plan or any other aspect of the project should be modified to provide better quality data.

Precision, bias, and completeness are discussed in Section 3.

SECTION 13: CORRECTIVE ACTION

For parameters that will be analyzed in the laboratory, the laboratory includes in its QAM and SOPs control charts indicating when a process is out of control and corrective actions are required.

For the Dissolved Oxygen field measurement, if values are obtained that are unusually high or low according to the field analyst's experience and judgment and compared to historical data, the field analyst will use the Winkler Kit to determine the Dissolved Oxygen. The Winkler Dissolved Oxygen value will be reported.

Because of the simplicity of its design, no comparable corrective actions will be taken for unusually high or low Transparency Tube values.

SECTION 14: QUALITY ASSURANCE REPORTS TO MANAGEMENT

The Project Leader will submit data to the MPCA Project Manager as specified in the contract. Prompt data submittal affords the opportunity to identify and correct sampling or analytical problems. The final report for each project will include a QA section summarizing the data quality information. The report will include the following:

- Assessment of such items as data accuracy and completeness
- Results of performance and/or system audits, if any
- Discussion of significant QA/QC problems, if any, and recommended solutions
- Discussion of whether the QA objectives were met and the resulting impact on decision making
- Limitations placed on the use of the data, if any

REFERENCES CITED

1. Standard Methods for the Examination of Water and Wastewater, 20th Edition, 1998.
2. Minnesota Department of Health Quality Assurance Manual, 2004.
3. Minnesota Department of Health Environmental Laboratory Handbook, FY 2004.

Appendix A

Surface Water Sampling - Equipment Cleaning and Decontamination

Materials Needed:

Phosphate-free detergent, tap water, acetone or isopropyl alcohol, hexane, 10% HCl, deionized water, personal safety gear, chemical-free paper towels/tissues, gloves, waste storage containers, plastic ground cloth for placing clean equipment, container for cleaning equipment (plastic tub), cleaning brushes with non-contaminating bristles.

Equipment Cleaning and Decontamination Steps:

1. Detergent Wash

    - Wash the equipment initially with phosphate-free detergent and tap water to remove visible dirt and contaminants.

2. Acid/Solvent Rinse for Specific Contaminants

    - Sampling for organics: First rinse with acetone or isopropyl alcohol, then finish with a hexane rinse.

    - Sampling for metals, nutrients, and/or general parameters: Rinse with 10% HCl.

    - Sampling for organics and metals, nutrients, and/or general parameters: First rinse with 10% HCl, then finish with an acetone/isopropyl alcohol/hexane rinse.

3. Do a final rinse three times with deionized water.

4. Let air-dry until moisture is completely evaporated.

Other Considerations:

1. All field equipment should be thoroughly cleaned and decontaminated at least annually, ideally at the beginning of the sampling season. Also clean after each sampling event at sites with heavy contamination.

2. Collect samples from lowest to highest suspected levels of contamination to minimize the chance of cross contamination.

3. Decontaminate equipment at a separate location from the sampling site.

Appendix B

Hand-Collected (Grab) Sampling

Standard Methods for Collection

Water is collected at the sampling point using one of the following methods depending upon physical accessibility:

1. triple sampler (MPCA design)
2. remote grab sampler (MPCA design - 2-liter Nalgene® bottle clamped to a telescoping pole)
3. sample bottle dip while wading
4. sample bottle dip through hole cut in ice

Follow bottle rinse and preservation methods as directed by the analyzing laboratory. The Minnesota Department of Health recommends that its bottles **not** be rinsed before sample collection. MDH sample bottles are pre-cleaned, disposable. Also, each lot is sampled for cleanliness as part of MDH's QA/QC Program. Repeat-use sampling equipment chambers that contact sample water should be rinsed thoroughly with sample water three times before water is collected to transfer to sample containers.

When grab sampling is suitable, samples should be collected along the sample site cross-section. Sample at a point that represents the water quality of the total instantaneous flow at the cross section. Avoid sampling points that are poorly mixed or affected by local temporary conditions such as ponding across part of the stream width, obviously disproportionate sediment load, or backwater conditions. If a site is poorly mixed across the stream, integrated sample across the stream width should be used, or another site should be chosen that is well mixed across the stream width.

Collect the sample at a middle depth in the water column without disturbing stream bed sediments or collecting floating materials from the surface. When grab sampling, the bottle should be lowered mouth down to the middle depth below the water surface then turned upward to collect the sample. Always stand downstream of the sampling point to avoid contaminating the sample. During ice conditions, keep ice and snow out of the sampling hole cut in the ice.

SAFETY FIRST!

If wading, as a general rule, if stream depth (in feet) multiplied by its velocity (feet/second) is greater than your height (in feet), then **DO NOT WADE!**

(Stream Depth) [ft.] x Stream Velocity [ft./sec.] > your height [ft.] = Do Not Wade!

Appendix C

Stage Monitoring

What to do when checking a monitoring site

Note - While not all stage monitoring stations are the same and some equipment specific needs may be missing from this section, the following, lists the general steps that need to be performed and the sequence in which they should be performed during a site visit.

General Information - In a perfect scenario, stage-monitoring equipment and added peripherals would be installed in the spring and removed in the fall at which time the seasonal data would be downloaded. However, while dramatic improvements in equipment have been made in the past few years it should never be assumed equipment will track or function correctly throughout the duration of the monitoring season. As a general rule a site should be visited and checked as often as every 1-2 weeks during very high flows, 2-3 weeks during high to moderate flows and about once every 4-5 weeks during low flows (even if a modem is installed). A transducer, stilling well, or bubbler will almost always provide an output number or stage value. Without visiting a site periodically, one is assuming, often incorrectly, this value is reflective of the true stage value. With periodic site visits, stage verifications are made adding credibility to the data set. If a problem exists, corrections can be made and data can be adjusted without losing too much integrity in the data set. The shorter the correction interval, the less integrity lost.

The following is a list of the steps that should be performed on site visits. Often, two or more field staff may visit the same site periodically during the monitoring season. Continuity in record keeping among staff visiting a site is imperative so that all collecting data are aware of any problems that may exist or adjustments that may have been made. Good notes and records are also invaluable when questions or discrepancies in stage arise during the calculation of loads and concentrations after the monitoring season has ended. Pertinent information should be recorded in the site book located in the enclosure box housing the datalogger as well as in the field technician's personal field book.

Steps:

1 **Measure and record true stage**. This is done by either; reading the staff gage, lowering the wire weight to the water surface and recording the value at this point, lowering a weighted tape measure from a defined reference point (RP) to the water surface and subtracting this value from the elevation of the reference point.

2 **Open enclosure box and check desiccant**- this is very important, most equipment will eventually be ruined if not properly desiccated.

- **Check Desiccant Indicator Card** - the indicator card may change color when exposed to ambient humidity levels thus it should be checked when the box is first opened - replace desiccant if needed.

3 **Download data from datalogger (*871A)**

- Record starting (option 2) and ending (option 3) storage locations in field books (personal and site).

- Advance to option 4, type in any number, advance again and the data will be downloaded to the storage module.
- In the back of your personal field book record the date, time, site, and datalogger stage value. This information is helpful in determining what data is for which site when the data is dumped from the storage module to a computer.
- **Note -** If the current starting storage location point is different than the ending storage location point on the last visit, the correct location value can be entered with the keyboard. Or, if for one reason or another you wish to download all the data recorded in the datalogger, key in a starting storage location value several units greater than the ending storage location value and then download.

4 Record datalogger stage value (*6A)

- The true stage and datalogger stage value should generally be within .04' of each other. If a discrepancy of greater than .07' in stage values exists contact your MPCA support person for help or adjust the offset if you are familiar with the equipment.

5 Check battery voltage (*610A)

- A battery of less than 12 volts should be changed. Always download data before changing the battery. Older CR10 dataloggers do not have an internal battery and the program will be lost if disconnected from the power source. To prevent this from happening, an additional set of 12V and ground (G) leads can be attached to the datalogger and hooked up to the replacement battery before the original battery is disconnected.
- Batteries charged by solar panels should maintain a charge of 13.5 volts.

6 Check rain gage for obstructions

- Rain gages often get plugged with sticks, leaves or bird droppings. Make sure the hole draining the collection bucket is open.

7 Take Notes

- Record date, time, general stream conditions such as flow level, appearance, water clarity, presence of biological organisms, algae blooms, etc.
- It is also very important to take note of any downstream obstructions such as log jams, beaver dams or any other conditions that may be causing backwater effects (elevated or non-typical stage level for a given flow). If backwater is suspected, flow measurements must be taken so stage values can be adjusted to fit the rating curve (if one has been developed) or temporarily rated while the backwater causing variable is present.
- If collecting samples, fill out the "**2004 Sampling Field Sheet.**"

Appendix D

Coliform Bacteria Sampling

Sample Collection, Preservation, and Storage

Because sterile conditions must be maintained during collection, preservation, storage, and analysis of indicator bacteria samples, specific procedures have been developed that must be strictly followed. These procedures vary with types of sampling equipment and source of sample (surface water, ground water, treated water, or waste water).

Surface-Water Sample Collection

The areal and temporal distribution of indicator bacteria in surface water can be as variable as the distribution of suspended sediment because bacteria commonly are associated with solid particles. To obtain representative data, use the same methods for collecting surface-water samples for bacteria analysis as for suspended sediment.

Quality Control.

Depending on the data-quality requirements, quality-control (QC) samples (blanks and replicates) can comprise from 5 to 30 percent or more of the total number of samples collected over a given period of time.

Collect and analyze field blanks to document that sampling equipment has not been contaminated.

Process field blanks before collecting the water sample:

1. Rinse sterile sampling equipment and containers with sterile buffered water.
2. Process sterile buffered water through sampling equipment and into sterile sample bottle and analyze for colony growth. If no growth is observed, the sample was collected using sterile procedures.

Hand-Dip Method

If the stream depth and (or) velocity is not sufficient to use a depth-and-width integrating method, collect a sample by a hand-dip method. Sampling still water or sampling at depth in lakes, reservoirs, estuaries, and oceans requires a sterile point sampler. Niskin, ZoBell, and Wheaton samplers hold a sterilizable bottle or bag. To collect a hand-dipped sample:

1. Open a sterile, narrow-mouth borosilicate glass or plastic bottle; grasp the bottle near the base, with hand and arm on downstream side of bottle.
2. Without rinsing, plunge the bottle opening downward, below the water surface. Allow the bottle to fill with the opening pointed slightly upward into the current.

3. Remove the bottle with the opening pointed upward from the water and tightly cap it, allowing about 2.5 to 5 cm of headspace. This procedure minimizes collection of surface film and avoids contact with the streambed.

As with surface water, most bacteria in ground and well water are associated with solid particles. Stable values of field measurements (turbidity, temperature, dissolved-oxygen concentration, pH, and specific electrical conductance) are important criteria for judging if a well has been sufficiently purged for collection of a representative ground-water sample for indicator bacteria analysis.

Sample Preservation and Storage

After collection, immediately chill samples in an ice chest or refrigerator at 1° to 4° C. Do not freeze samples. Begin analysis as quickly as possible, preferably within 1 hour but not more than 6 hours after sample collection, *to minimize changes in the concentration of indicator bacteria*.

MPCA Environmental Outcomes Division policy is as follows:

The maximum 6-hour holding time must be strictly observed if the sampling is being done in conjunction with a possible enforcement action. A chain-of-custody form must also be used.

If the sampling is not for possible enforcement purposes, the maximum holding time is 24-hours and a chain-of-custody form need not be used.

Appendix E

Dissolved Oxygen Meter General Instructions

Meter Preparation

- Turn meter on and allow to stabilize for at least 15 minutes before use
- Inspect the probe
- Zero salinity, as needed
- Zero the meter (mechanical and/or electronic)
- Check battery voltage(s) (red line)
- Shake water droplets from membrane, if present
- Place probe in calibration chamber
- Calculate calibration setting using one of the following: 1) temperature and barometric pressure or altitude or 2) titrate using the Winkler kit
- Allow meter to stabilize for at least 15 minutes

Precalibration

- Adjust readout to calibration setting, if necessary
- Record calibration data

Testing Sample

- Place probe in sample
- Continuously stir sample
- Record test result

Postcalibration

- Do after each sample batch or every two hours, whichever comes first
- Place probe in calibration chamber
- Record calibration data

Table 10. Oxygen Solubility Table

Oxygen Solubility Table (elevation)

Dissolved-oxygen concentration (mg/L) in water as a function of temperature and barometric pressure (salinity = 0 ppt).

	Barometric pressure, millimeters of mercury									
Temp. (°C)	735	740	745	750	755	760*	765	770	775	780
0	14.12	14.22	14.31	14.41	14.51	14.60	14.70	14.80	14.89	14.99
1	13.73	13.82	13.92	14.01	14.10	14.20	14.29	14.39	14.48	14.57
2	13.36	13.45	13.54	13.63	13.72	13.81	13.90	14.00	14.09	14.18
3	13.00	13.09	13.18	13.27	13.36	13.45	13.53	13.62	13.71	13.80
4	12.66	12.75	12.83	12.92	13.01	13.09	13.18	13.27	13.35	13.44
5	12.33	12.42	12.50	12.59	12.67	12.76	12.84	12.93	13.01	13.10
6	12.02	12.11	12.19	12.27	12.35	12.44	12.52	12.60	12.68	12.77
7	11.72	11.80	11.89	11.97	12.05	12.13	12.21	12.29	12.37	12.45
8	11.44	11.52	11.60	11.67	11.75	11.83	11.91	11.99	12.07	12.15
9	11.16	11.24	11.32	11.40	11.47	11.55	11.63	11.70	11.78	11.86
10	10.90	10.98	11.05	11.13	11.20	11.28	11.35	11.43	11.50	11.58
11	10.65	10.72	10.80	10.87	10.94	11.02	11.09	11.16	11.24	11.31
12	10.41	10.48	10.55	10.62	10.69	10.77	10.84	10.91	10.98	11.05
13	10.17	10.24	10.31	10.38	10.46	10.53	10.60	10.67	10.74	10.81
14	9.95	10.02	10.09	10.16	10.23	10.29	10.36	10.43	10.50	10.57
15	9.73	9.80	9.87	9.94	10.00	10.07	10.14	10.21	10.27	10.34
16	9.53	9.59	9.66	9.73	9.79	9.86	9.92	9.99	10.06	10.12
17	9.33	9.39	9.46	9.52	9.59	9.65	9.72	9.78	9.85	9.91
18	9.14	9.20	9.26	9.33	9.39	9.45	9.52	9.58	9.64	9.71
19	8.95	9.01	9.07	9.14	9.20	9.26	9.32	9.39	9.45	9.51
20	8.77	8.83	8.89	8.95	9.02	9.08	9.14	9.20	9.26	9.32
21	8.60	8.66	8.72	8.78	8.84	8.90	8.96	9.02	9.08	9.14
22	8.43	8.49	8.55	8.61	8.67	8.73	8.79	8.84	8.90	8.96
23	8.27	8.33	8.39	8.44	8.50	8.56	8.62	8.68	8.73	8.79
24	8.11	8.17	8.23	8.29	8.34	8.40	8.46	8.51	8.57	8.63
25	7.96	8.02	8.08	8.13	8.19	8.24	8.30	8.36	8.41	8.47
26	7.82	7.87	7.93	7.98	8.04	8.09	8.15	8.20	8.26	8.31
27	7.68	7.73	7.79	7.84	7.89	7.95	8.00	8.06	8.11	8.17
28	7.54	7.59	7.65	7.70	7.75	7.81	7.86	7.91	7.97	8.02
29	7.41	7.46	7.51	7.57	7.62	7.67	7.72	7.78	7.83	7.88
30	7.28	7.33	7.38	7.44	7.49	7.54	7.59	7.64	7.69	7.75
31	7.16	7.21	7.26	7.31	7.36	7.41	7.46	7.51	7.56	7.62
32	7.04	7.09	7.14	7.19	7.24	7.29	7.34	7.39	7.44	7.49
33	6.92	6.97	7.02	7.07	7.12	7.17	7.22	7.27	7.31	7.36
34	6.80	6.85	6.90	6.95	7.00	7.05	7.10	7.15	7.20	7.24
35	6.69	6.74	6.79	6.84	6.89	6.93	6.98	7.03	7.08	7.13
36	6.59	6.63	6.68	6.73	6.78	6.82	6.87	6.92	6.97	7.01
37	6.48	6.53	6.57	6.62	6.67	6.72	6.76	6.81	6.86	6.90
38	6.38	6.43	6.47	6.52	6.56	6.61	6.66	6.70	6.75	6.80
39	6.28	6.33	6.37	6.42	6.46	6.51	6.56	6.60	6.65	6.69
40	6.18	6.23	6.27	6.32	6.36	6.41	6.46	6.50	6.55	6.59

A barometric pressure of 760 millimeters of mercury is considered sea level.

Appendix F

Transparency Tube Field Sampling Protocol

Transparency

Collect your water sample in a clean bucket or bottle at mid-stream and depth.

1. Wading or From Stream Bank.

Always sample safely - don't wade into fast-moving water or areas of unknown depth. If you cannot sample safely, make visual observations only (Appearance). If a sample from mid-stream and depth is not possible, avoid stagnant water and sample as far from the shoreline as is safe. Try not to stir up the bottom. Face upstream as you fill your bucket. Avoid collecting sediment from the stream bottom or materials from the water surface.

2. From Atop a Bridge or Culvert.

With a rope tied to its handle, lower a bucket down to the stream and collect water. Pull the bucket back up, taking care not to bounce the rope or bucket on the side of the bridge or culvert. Take your tube readings in open conditions. Avoid direct sunlight by turning your back to the sun if necessary. Pour the water from your bucket into the tube until the symbol on the bottom is no longer visible. While looking down into your tube, open the valve at the bottom and slowly release water until you can JUST begin to make out the symbol on the bottom. Note this depth. Release a bit more water until the symbol is visible. Note this depth.

Record the average of the two depths noted in steps 3 and 4 on your data sheet to the nearest centimeter. If the symbol is still visible when your tube is full, indicate this on the data sheet (e.g., > 60 cm).

Stream Stage

Estimate the water level each time you sample. L=low; N=normal; H=high

Appearance

Each day that you sample, record the one number that best describes the appearance of stream water within one meter of your sampling site.

1 = Clear (crystal clear, transparent water)
2 = Milky (not quite crystal clear; cloudy white or gray)
3 = Foamy (natural or from pollution; generally detergents, nutrients or dissolved organic material) Several inches of foam that does not brush apart easily is generally due to pollution of some sort.
4 = Tea-colored (clear but tea-colored due to wetland or bog influences)
5 = Muddy (cloudy brown due to high sediment levels)
6 = Green (may indicate excess nutrients released into the stream)

7 = Green **or** Muddy **plus one or more of the following**:

- extensive floating scum on the stream surface or washed up on shore
- strong foul odor

Recreational Suitability

Use the one number each day that you sample that best describes your opinion of how suitable the stream water is for recreation and enjoyment.

1 = Beautiful, could not be better
2 = Very minor aesthetic problems. Excellent for body-contact recreation, e.g., swimming, wading, frog-catching
3 = Body-contact recreation and aesthetic enjoyment slightly impaired
4 = Recreation potential and level of enjoyment of the stream substantially reduced, e.g., you would not swim but would boat or canoe
5 = Swimming and aesthetic enjoyment of the stream is nearly impossible

Appendix G

QA Field Sampling Procedures

Sampler Blanks

A sampler blank (also commonly referred to as a rinsate blank or equipment blank) is a sample of distilled water that is rinsed through the sampling device and collected for analysis. Ed Norwig will be maintaining jugs of distilled water at the warehouse that can be used for sampler blanks. Please try to use the plastic containers that are labeled "DI Water For Sampler Blanks Only". These containers are located on the metal storage shelves near Ed's desk. If you have trouble locating these containers of if they are empty please notify Ed Norwig. If you plan on using more than one container for a trip, please contact Ed well in advance of your trip so that he can obtain the necessary containers.

The first step in collecting a sampler blank is to decontaminate the sampling device in the same manner that is used to collect your regular samples. For example, if you clean the sampling device with detergent and rinse with DI water, then conduct this same procedure before you collect the blank. **If you normally rinse your sampling device with sample water before collecting your sample, then conduct this rinse with DI water instead of sample water** – this will prevent any residual sample water from being detected in your results. Try to eliminate as much of the rinse water from the sampling device as possible before you collect the blank.

To collect the blank, fill the sampling device with distilled water and transfer the water to the appropriate collection bottles. Handle the device as close to your normal sampling procedure as possible: agitate the sampling device in the same manner, try to leave the water in the sampling device for the same amount of time, and collect the same volume of water.

Trip Blanks

Trip Blanks are sample bottles of deionized water that are filled before going out into the field and are carried along the entire sampling trip in the cooler. They are typically obtained ahead of time from the laboratory and are preserved in the same manner as the regular sample. Trip blanks are generally only used when collecting samples for volatile organic compounds.

Field Duplicates

A field duplicate is a second sample taken right after an initial sample in the exact same location. Field duplicates assess the sampler's precision, laboratory precision, and possible temporal variability. The duplicate sample should be collected in the exact same manner as the first sample, including the normal sampling equipment cleaning procedures.

Lab Sheets

A column labeled "QA Type" has been added to the lab sheets. If you are collecting a QA sample, fill in the type of QA sample in this column. Leave the column blank if it is a normal sample. The abbreviations for the QA samples are as follows:

SB = sampler blank FD = field duplicate TB = trip blank

The sampler blanks and field duplicate samples will have the exact same station, date, time, depth, and substation as the samples with which they are associated. The only thing distinguishing the samples apart will be the specified sample type in the "QA Type" column. So please remember to fill in this column with the QA sample type (SB or FD). Since the trip blanks are associated with an entire sampling trip, these samples will not have a station or time associated with them. Fill in the date of the trip and the QA sample type (TB).

Appendix H

Specific Conductance Measurement

Measurement

In situ measurement generally is preferred for determining the conductivity of surface water; down-hole or flow-through-chamber measurements are preferred for ground water. Be alert to the following problems if conductivity is measured in an isolated (discrete) sample or sub-sample:

1. The conductivity of water can change over time as a result of chemical and physical processes such as precipitation, adsorption, ion exchange, oxidation, and reduction--Do not delay making conductivity measurements.

2. Field conditions (rain, wind, cold, dust, direct sunlight) can cause measurement problems--Shield the instrument to the extent possible and perform measurements in a collection chamber in an enclosed vehicle or an on-site laboratory.

3. For waters susceptible to significant gain and loss of dissolved gases, make the measurement within a gas-impermeable container (Berzelius flask) fitted with a stopper--Place the sensor through the stopper and work quickly to maintain the sample at ambient surface-water or ground-water temperature.

4. Avoid contamination from the pH electrode filling solution. Measure conductivity on a separate discrete sample from the one used for measuring pH; in a flow-through chamber, position conductivity sensor upstream of the pH electrode.

Conductivity must be measured in the field.

5. Document the precision of your measurements. Precision should be determined about every tenth sample or more frequently, depending on study objectives. Successive measurements should be repeated until they agree within 5 percent at conductivity ≤ 100 µS/cm or within 3 percent at conductivity >100 µS/cm.

6. The conductivity measurement reported must account for sample temperature. If using an instrument that does not automatically temperature compensate to 25°C, record the uncompensated measurement in your field notes, along with the corrected conductivity value. Use correction factors supplied by the instrument manufacturer.

Surface Water

Surface-water conductivity should be measured in situ, if possible; otherwise, determine conductivity in discrete samples collected from a sample splitter or compositing device. Filtered samples may be needed if the concentrations of suspended material interfere with obtaining a stable measurement. Conductivity measurements in flowing surface water should represent the cross-sectional mean or median conductivity at the time of observation. Any deviation from this convention must be documented in the data base and with the published data.

Follow the steps listed below:

1. Calibrate the conductivity instrument system at the field site after equilibrating the buffers with stream temperature.
2. Record the conductivity variation from a cross-sectional profile on a field form and select the sampling method.
    - **Flowing, shallow stream**--wade to the location(s) where conductivity is to be measured.
    - **Stream too deep or swift to wade--**lower a weighted conductivity sensor from a bridge, cableway, or boat. Do not attach weight to the sensor or the sensor cable.
    - **Still-water conditions--**measure conductivity at multiple depths at several points in the cross section.
3. Immerse the conductivity and temperature sensors in the water to the correct depth and hold there (no less than 60 seconds) until the sensors equilibrate to water conditions.
4. Record the conductivity and corresponding temperature readings without removing the sensors from water.
    - Values should stabilize quickly to within 5 percent at conductivity ≤ 100 µS/cm and within 3 percent at conductivity >100 µS/cm.
    - Record the median of the stabilized values on field forms.
    - If the readings do not meet the stability criterion after extending the measurement period, record this difficulty in the field notes along with the fluctuation range and the median value of the last five or more readings.
5. When the measurement is complete, remove the sensor from the water, rinse it with de-ionized water, and store it.
6. Record the stream conductivity on the field forms. If the measurement was taken in still water, record the median (middle value) of three readings.

Calibration

Conductivity systems must be calibrated before every water-quality field trip and again at each site before samples are measured. Calibration readings are recorded in the instrument log book and on field forms at the time the instrument is calibrated. Remember, the temperature sensor on the conductivity sensor must be calibrated and District certified within the past 4 months.

Calibration and operating procedures differ, depending on instrument and sensor type. Some conductivity sensors may need to be soaked overnight in deionized water before use. Check the manufacturer's instructions. Some analog instruments require an initial mechanical zero adjustment of the indicator needle. For a cup-type cell, calibration and measurement procedures described for the dip-type cell apply; the only difference is that standards are poured directly into

the cup-type cell. When using a dip-type cell, do not let the cell rest on the bottom or sides of the measuring container.

Calibrate at your field site—bring standards to sample temperature.

Conductivity systems normally are calibrated with at least two standards. Calibrate sensors against a standard that approximates sample conductivity and use the second standard as a calibration check. The general procedures described in steps 1-15 below apply to most instruments used for field measurements-check the instrument manual for specific instructions.

- Inspect the instrument and the conductivity sensor for damage. Check the battery voltage. Make sure that all cables are clean and connected properly.
- Turn the instrument on and allow sufficient time for electronic stabilization.
- Select the correct instrument calibration scale for expected conductivity.
- Select the sensor type and the cell constant that will most accurately measure expected conductivity.
- Select two conductivity standards that will bracket the expected sample conductivity. Verify that the date on the standards has not expired.
- Equilibrate the standards and the conductivity sensor to the temperature of the sample. Put bottles of standards in a minnow bucket, cooler, or large water bath that is being filled with ambient water. Allow 15 to 30 minutes for thermal equilibration. Do not allow water to dilute the standard.
- Rinse the conductivity sensor, the thermometer (liquid-in-glass or thermistor), and a container large enough to hold the dip-type sensor and the thermometer. First**,** rinse the sensor, the thermometer, and the container three times with deionized water. Next**, rinse** the sensor, the thermometer, and the container three times with the standard to be used.
- Put the sensor and the thermometer into the rinsed container and pour in fresh calibration standard.
- Measure water temperature. **Accurate conductivity measurements depend on accurate temperature measurements or accurate temperature compensation.** If the sensor contains a calibrated thermistor, use this thermistor to measure water temperature. If using a manual instrument without a temperature display or temperature compensation, adjust the instrument to the temperature of the standard using a calibrated liquid-in-glass or a thermistor thermometer.
- Agitate a submersible-type conductivity sensor up and down under the solution surface to expel air trapped in the sensor. Read the instrument display. Agitate the sensor up and down under the solution surface again, and read the display. Repeat the procedure until consecutive readings are the same.
- Record the instrument reading and adjust the instrument to the known standard value. For nontemperature-compensating conductivity instruments, apply a temperature-correction factor to convert the instrument reading to conductivity at 25°C. The correction factor depends to some degree on the specific instrument used-use the temperature-correction factor recommended by the manufacturer. If this is not available, use correction factors from table 6.3-3. If an instrument cannot be adjusted to a known calibration standard

value, develop a calibration curve. After temperature compensation, if the percentage difference from the standard exceeds 5 percent, refer to the troubleshooting guide.

Record in the instrument log book and on field forms: the temperature of the standard solution, the known and the measured conductivity of the standard solution (including ± variation), and the temperature-correction factor (if necessary).

Discard the used standard into a waste container. Rinse the sensor, thermometer, and container thoroughly with de-ionized water.

Repeat this process for the second conductivity standard. The purpose for measuring a second standard is to check instrument calibration over the range of the two standards. The difference from the standard value should not exceed 5 percent. If the difference is greater than 5 percent, repeat the entire calibration procedure. If the second reading still does not come within 5 percent of standard value, refer to the troubleshooting guide or calibrate a backup instrument. **Switching instrument calibration scales could require recalibration.** Record in the instrument log book and on field forms the calibration data for the second standard.

Do not use expired standards.
Never reuse standards.

Maintenance, Cleaning, and Storage

As soon as possible after delivery to the office, label conductivity standards with the date of expiration. Discard standards that have expired, been frozen, have begun to evaporate, or that were decanted from the storage container.

Maintenance

Maintenance of conductivity equipment includes periodic office checks of instrument operation. To help keep equipment in good operating condition, protect the conductivity system from dust and excessive heat and cold. Keep all cable connectors dry and free of dirt and extraneous matter. Protect connector ends in a clean plastic bag when not in use.

Sensor Cleaning

Conductivity sensors must be clean to produce accurate results; residues from previous samples can coat surfaces of sensors and cause erroneous readings. Clean sensors thoroughly with de-ionized water before and after making a measurement. This is sufficient cleaning in most cases. Remove oily residue or other chemical residues (salts) with a detergent solution. Sensors can soak in detergent solution for many hours without damage. If oil or other residues persist, dip the sensor in a dilute hydrochloric acid solution. **Never leave the sensor in contact with acid solution for more than a few minutes.** Check the manufacturer's recommendations before using acid solution on sensors. Clean carbon and stainless steel sensors with a soft brush. Never use a brush on platinum-coated sensors.

Sensor Storage

Refer to the manufacturer's recommendations. Sensors may be temporarily stored in de-ionized water between measurements and when the system is in daily use. For long-term storage, store sensors clean and dry.

CAUTION: Before handling conductivity standards or acids, refer to Material Safety Data Sheets (MSDS) for safety precautions.

Some of the procedures recommended herein for equipment operation may be out of date if the equipment being used is different from that described or incorporates more recent technological advances—follow the manufacturer's instructions.