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**Quality Assurance Project Plan
for Water Quality Monitoring and Modeling
of the River Raisin Watershed,
Monroe, Lenawee, Jackson, Hillsdale Counties**

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1.0 Project Management

1.1 Responsible Parties

The River Raisin Watershed Council (RRWC) is the grant recipient. The RRWC, Jill Kelley, and graduate students from the School of Natural Resources and Environment at the University of Michigan will provide data collection and analysis. Water quality analysis will be provided by the University of Michigan with assistance from the Saline and Tecumseh wastewater treatment plants and the Adrian water treatment plant. Stantec will oversee data analysis and planning and developing the hydrologic and water quality model. JFNew will assist with quality control review.

Table 1. Contact information for key personnel

Name	Responsibility	Address	Phone/e-mail
Gayle Mitchell, RRWC	Oversee overall project, coordinate meetings, and perform quality control review	1042 Sutton Rd, Suite #3 Adrian, MI 49221	517.265.5599 gayle.mitchell@comcast.net
Jill Kelley, Independent Consultant	Collect existing water quality and GIS data to be integrated into model.	3154 Cobblestone Ridge Tecumseh, MI 49286	517.423.8395 jill.kelley@comcast.net
Heather Dermyer, Stantec	Plan data collection, model planning, perform quality control review and write final reports.	3959 Research Park Dr Ann Arbor, MI 48108	734.214.1862 hdermyer@stantec.com
Chris Rybak, Stantec	Plan model, perform quality control review and write final reports.	3959 Research Park Dr Ann Arbor, MI 48108	734.214.2537 crybak@stantec.com
Nate Borsch, Stantec	Engineering technician to build model	3959 Research Park Dr Ann Arbor, MI 48108	734.761.1010 borschn@umich.edu
Dr. David Allan	Oversight for water quality sampling team	School of Natural Resources and Environment, University of Michigan, Ann Arbor, 48109	734-764-6553 dallan@umich.edu

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Robert Scull Saline WPCF	E. coli testing	Saline Pollution Control Facility Robert Scull 100 North Harris Street Saline, MI 48176- 1642	734-429-4907 X224
Tecumseh WWTP	E. coli testing	Tecumseh Wastewater Treatment Plant 710 East Chicago Blvd. Tecumseh, MI 49286	517-423-6292
Shane Horn Adrian WTP	E. coli testing	Adrian Water Treatment Plant Shane Horn 815 Bent Oak Avenue Adrian, MI 49221	517-263-2161
Scott Dierks, JFNew	Quality control review	PO Box 7780 Ann Arbor 48107	734-222-9690 sdierks@jfnew.com

1.2 Documentation

This Quality Assurance Project Plan (QAPP) will be distributed to the Michigan Department of Environmental Quality (MDEQ) Nonpoint Source (NPS) Unit and the River Raisin Watershed Council. Final reports of the Water Quality Analysis and Model will be summarized in the Watershed Management Plan. Digital files of the data, model and reports will be made available to other people or organizations upon completion.

1.3 Problem Definition

The River Raisin watershed covers roughly 1,072 square miles and contains approximately 429 lakes and ponds, more than 3,000 miles of artificial drainage systems, and 60 dams. Located in southeast Michigan, the River Raisin flows through northeast Hillsdale County, southeast Jackson County, southwest Washtenaw County, eastern Lenawee County, northern Fulton County in Ohio and mid-Monroe County before emptying into Lake Erie.

Several natural areas in the River Raisin have regional ecological significance. The main stem of the river above Adrian has some of the richest mussel beds in the state of Michigan. Twenty-one species of mussels have been identified along with eighty species of fish----most of the original fishery. There are also several high quality, mesic hardwood forests, riparian and floodplain forests, prairie fens and remnant oak barrens

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in the upper watershed that support rare species such as the Eastern Massassauga rattlesnake, Blanchard's Cricket frog, Indiana Bat, and Spotted turtle.

The lower 2.6 miles of the River Raisin have been identified by the International Joint Commission as one of Michigan's fourteen Areas of Concern (AOC) due to PCB and heavy metal contamination of fish and sediments. In addition, the Detroit Edison Monroe Power Plant at the mouth of the River Raisin remains a significant obstacle for fish migration, typically using the entire river's flow as cooling water.

In 2000, agriculture accounted for 65% of the watershed's land use, urbanized areas 11%, wetlands 8%, and forested and grassland areas 7% each. There are 41 National Pollutant Discharge Elimination System (NPDES) point-source dischargers and 13 public water supply systems in the watershed. During low flow periods most of the river and its tributary flow can be removed for consumptive uses. Some urbanizing areas are experiencing explosive growth pressures. Recently, massive 1,000+ unit single-family housing developments have been proposed for Milan and Saline. These watershed pressures have created sediment, nutrient, pesticide, pathogen, heavy metals loads, flow instability, and habitat impairments. But one of "...the greatest impediment[s] to beneficial change in the River Raisin is the poor public image of the river and its tributaries (MDNR 1998)".

Currently there are 12 distinct Clean Water Act 303d water quality impaired reaches and lakes along the Raisin River and its tributaries. Four reaches have Total Maximum Daily Loads (TMDLs) for untreated sewage discharge, pathogens, and PCBs. Other water quality impairments include pesticides, metals, and turbidity. Fish consumption advisories due to PCBs have also been issued for three locations on the river.

The existing data compiled for this project will be used to calibrate a Non-Point Source (NPS) watershed model. This model runs on daily time steps and will be used to simulate recent and proposed conditions over multi-year modeling windows. The field data collected as part of this project will not be used directly to calibrate the model. This collected data will be compared to the model data on a qualitative basis, but will be primarily used to help prioritize watershed problems and solutions.

1.4 Project Description

The MDEQ requires watershed management plans funded through Clean Water Act Section 319 grants to quantify sources of pollutants and determine recommendations for improvements. Prioritization of watershed water quality problems and solutions will draw upon a multi-tiered approach. This approach includes 1) solicitation of stakeholders for existing data and problem identification, 2) hydrologic data acquisition, 3) macroinvertebrate sampling and analysis, 3) collection and analysis of water quality data, and 4) the use of a hydrologic and water quality GIS-based model to integrate the hydrology and water quality data.

In such a large watershed, a GIS-based model will help to efficiently estimate existing NPS loads and project the impacts of watershed land use changes and recommended

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improvements. We will use the GIS-based Soil and Water Assessment Tool (SWAT) to model existing and projected conditions in the watershed. This watershed scale model, developed by Dr. Jeff Arnold for the USDA Agricultural Research Service (ARS), predicts the impact of land management practices on water, sediment and agricultural chemical yields in large, complex watersheds with varying soils, land use and management conditions over long periods of time (Neitsch et al. 2002). SWAT uses land cover, elevation and soils data, climatological information, point source loadings and in-stream characteristics (e.g. dams) to identify sediment, nutrient, and other pollutant loads from individual subwatersheds to the mouth of the basin. It will also be used to assess predicted load reductions for a suite of proposed BMPs for future design scenarios.

SWAT has been used extensively in the U.S. for TMDL applications. Examples of watershed management plans which have utilized SWAT include the St. Joseph River in Michigan and Stillwater River in Ohio. SWAT has also been incorporated into US EPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) system.

Two sets of hydrologic and water quality data will be collected. The first set of data will consist of at least three dry and three wet weather synoptic surveys to assess dry and wet weather nutrient and *E. coli* concentrations and loads from each of the ten major subwatersheds of the River Raisin. This would be the first synoptic water quality survey that includes stations in each of the river's major subwatersheds. The second set of data, including USGS gage site flows and long-term data from the Heidelberg College Water Quality monitoring site near Monroe. These data sets will be used to calibrate the SWAT model.

Because the SWAT model works on a daily time step for assessing seasonal and annual pollutant loads and trends and will be calibrated to historical data, the information collected for the synoptic surveys will be used for comparative purposes and not as a supplemental calibration data set. The synoptic surveys will be used to compare relative concentrations and loads between the subwatersheds and to check relative magnitudes in the SWAT model. Due to timing constraints, the SWAT model needs to be calibrated in 2006, while the synoptic surveys will be conducted in 2006 and in 2007. In addition, as time and resources warrant, we have created a sufficiently flexible work plan to perform some limited upstream sampling if hot spots are found during the synoptic surveys. This supplemental sampling and analysis will encompass up to an additional 40 samples over the two-year study period. Details of the monitoring procedure are covered in Section 3.2 below.

Only sites with long-term data sets will be used to calibrate the SWAT model. These include USGS stream flow real-time and historic gage sites, NOAA and SEMCOG rain gages, and the Heidelberg College Water Quality Laboratory data from their site near Monroe. Because the Heidelberg samples have been collected at the USGS gage and analyzed for major nutrients and suspended solids since 1982, it has been chosen as the primary water quality data source for model calibration.

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Three USGS gage locations are currently available within the River Raisin watershed, located at Manchester, Adrian and Monroe. Parameters that are available include discharge (cubic feet per second) and gage height (feet) recorded in 15-60 minute intervals.

Approximately 50 NOAA and 10 SEMCOG precipitation stations currently exist in or near the watershed. Other local agencies will be contacted to determine if other rain gages are available locally. The rain gages typically record the time and amount of rainfall within 0.01-inch. One representative station will be designated for each subwatershed in the SWAT model.

The model will be built beginning in Summer 2006 and calibration will be completed in Fall 2006. Synoptic water quality sampling will be conducted in Summer 2006, with follow-up sampling in 2007. Multiple BMP scenarios will be modeled during Spring 2007. The final report will summarize the findings and recommendations by Fall 2007.

1.5 Data Quality Objectives

The primary Quality Assurance (QA) objective is to develop and implement procedures for valid field sampling methods, laboratory analysis, and data management. The QA characteristics of representativeness, completeness, precision, accuracy and comparability will determine whether high quality data is generated during the investigation. Specific objectives have been established to develop sampling protocols for quantitative and qualitative measurements, applicable documentation, and sample handling procedures. These objectives were established based on site conditions described in Section 2.1 and knowledge of available measurement systems. The use of field procedures, calculations, and evaluations is subject to the conditions of this QAPP as described in the following sections.

1.5.1 Qualitative Quality Assurance Objectives

Representativeness

Representativeness is the characteristic that indicates the degree to which sample data accurately and precisely represents site conditions and is dependent on the variability of sampling and analytical procedures. For water quality monitoring, a representative sample is one that accurately reflects the chemical composition and the biological and physical characteristics of the whole stream at the sampling point at an instant.

Proper sampling protocols will be used to assure that the samples collected are representative of field conditions. Sample handling protocols, including such tasks as storage, transportation, and preservation, will be used to protect the representativeness of the samples gathered during the project. Proper documentation in the field and the laboratory will establish that these protocols designed to preserve the representativeness of the samples have been followed and that sample identification and integrity has been preserved

Comparability

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Comparability is the characteristic that reflects the degree of confidence with which one set of data can be compared to another. The use of consistent sampling and analytical methodologies as presented in this QAPP will ensure that comparability is maintained during the sampling period.

1.5.2 Quantitative Quality Assurance Objectives

Precision

Precision is the characteristic that reflects the ability to replicate a previously obtained value using identical procedures. Precision will be measured as the degree of agreement between duplicate analysis results. Precision will be maximized by using consistent sampling methods and analytical procedures as described in the monitoring approach section of this QAPP.

All field personnel will be instructed on sampling techniques, Chain-of-Custody protocol, and sample handling to ensure consistency of sample collection and handling. Personnel will also be given a site walk-through to assure familiarity with the site.

Field precision will be evaluated by collecting and analyzing at least one duplicate sample per group of ten samples, or at least one duplicate sample per event, gathered for analytical evaluation. Since standard sampling procedures will be used, no additional duplicates are required to assess impacts from any changes in sampling team composition.

The precision of field measurements for all field instrumentation will be assessed by periodically obtaining duplicate testing of samples in the field at a frequency of one duplicate for every ten samples collected.

Laboratory data precision will be assessed by using within-run duplicates, mixed control sample duplicates, control samples, and matrix spike duplicates as part of the analytical procedures. The precision of calculations and evaluations performed with the data generated during the project is assured through review by experienced project staff.

Accuracy

Accuracy is the characteristic that reflects the degree to which a measured value agrees with the expected or true value associated with the application of concern.

Field data accuracy will be assured through proper calibration and maintenance of field instruments. Portable field instruments will be calibrated and maintained in accordance with the manufacturer's recommendations. Each instrument will be tested before each sampling period. Staff will practice all measurement techniques prior to entering the field to ensure familiarity with the procedure.

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Laboratory data accuracy will be assessed by using reference standards, matrix spikes, blank spikes, and surrogates as part of the analytical procedures. The results will be reviewed for compliance with the control limits established for the approved analytical methods.

Accuracy of calculations and evaluations performed with the data generated during the project is assured through review by experienced project staff.

Completeness

Completeness is the characteristic defined as the measure of the amount of valid data obtained compared to the amount that was specified to be obtained under normal conditions. The amount of valid data specified is established based on the measurements required to accomplish project objectives. The extent of completeness must be reviewed on a relative basis for sample collection activities, since the required amount of valid data anticipated prior to data collection may not accurately define the amount of data necessary to render a correct decision.

1.6 Training

All water quality sampling and analyses will be conducted by University of Michigan (UM) graduate students under the direction of Dr. Allan and with support from coordinating laboratories. Water quality collection and laboratory analysis training sessions will be provided by Dr. Allan. He will accompany each sampling team on the first two rounds of sampling. All students will visit the sampling sites before acquiring data to familiarize themselves with the site, access, and any safety concerns.

1.7 Documentation and Records

Data from each sampling site visit will be recorded on a field data sheet (Appendix A). All samples will be accompanied by a chain of custody sheet (Appendix C) and laboratory data sheets. All data sheets, chain of custody sheets, and results will be maintained by Dr. Allan at the School of Natural Resources and Environment on the main campus of the University of Michigan. Records will be maintained for at least three years following completion of the project. Electronic copies of field and Quality Assurance Quality Control (QA/QC) data will also be submitted to and maintained indefinitely in the office of the RRWC.

2.0 Study Design

The synoptic surveys will be used to compare relative concentrations and loads among the subwatersheds and to check relative magnitudes in the SWAT model, as described in Section 1.4. Details of the monitoring procedure are covered in Section 3.0.

2.1 Synoptic Water Quality Surveys

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The synoptic water quality surveys will be conducted at 24 sites (Table 2 and Figure 1) for up to six separate surveys in 2006. Follow-up sampling will be conducted in 2006 and in 2007 as feasible to further isolate hot spots. These water quality sampling stations are the same stations for the macroinvertebrate surveys proposed for the watershed management plan.

Dry weather surveys will be conducted after at least four days without rainfall (or less than a total of 0.05 inches over 96 hours). Wet weather surveys will be conducted as feasible. Because SWAT is not an event-based model, the data collected during wet weather will not be used for model calibration; therefore, we do not feel that setting strict wet weather size and timing requirements is necessary. We will try to focus wet weather sampling on events that cover the entire basin, rather than on storms with spatially limited rainfall coverage (such as convective storms). The intent of the sampling is to create a comparative load and concentration picture across the ten major subwatersheds.

Table 2. Water Quality Sampling Sites

Site	Sub-basin	Water	Location	Cross Street
BC1	Black Creek	TBD	TBD	TBD
BC2	Black Creek	TBD	TBD	TBD
E1	Evans	Evans	Tecumseh	Maumee St.
E2	Evans	TBD	TBD	TBD
G1	Goose	Goose	Brooklyn	M-50
G2	Goose	TBD	TBD	TBD
IC1	Iron Creek	TBD	TBD	TBD
IC2	Iron Creek	TBD	TBD	TBD
LRR1	Little River	Little River	Petersburg	Brewer Rd.
LRR2	Little River	TBD	TBD	TBD
RR1	River Raisin	River Raisin	Monroe	Telegraph Rd.
RR2	River Raisin	River Raisin	Monroe	Ida-Maybee
RR3	River Raisin	River Raisin	Dundee	M-50
RR5	River Raisin	River Raisin	Manchester	Sharon Valley
RR6	River Raisin	River Raisin	Tecumseh	Blood Rd.
RR7	River Raisin	River Raisin	Clinton	M-52
S2	Saline River	Saline River	Milan	Wilson Park
S3	Saline River	Saline River	Saline	Millpond Park
S4	Saline River	Wood	Pittsfield	Maple Rd
S5	Saline River	Pittsfield	Pittsfield	Moon Rd
SBM1	Macon	South	Dundee	Petersburg Rd
SBM2	Macon	TBD	TBD	TBD
SBR1	South	South	Adrian	Heritage Park
SBR2	South	South	Cadmus	Brenner Rd.

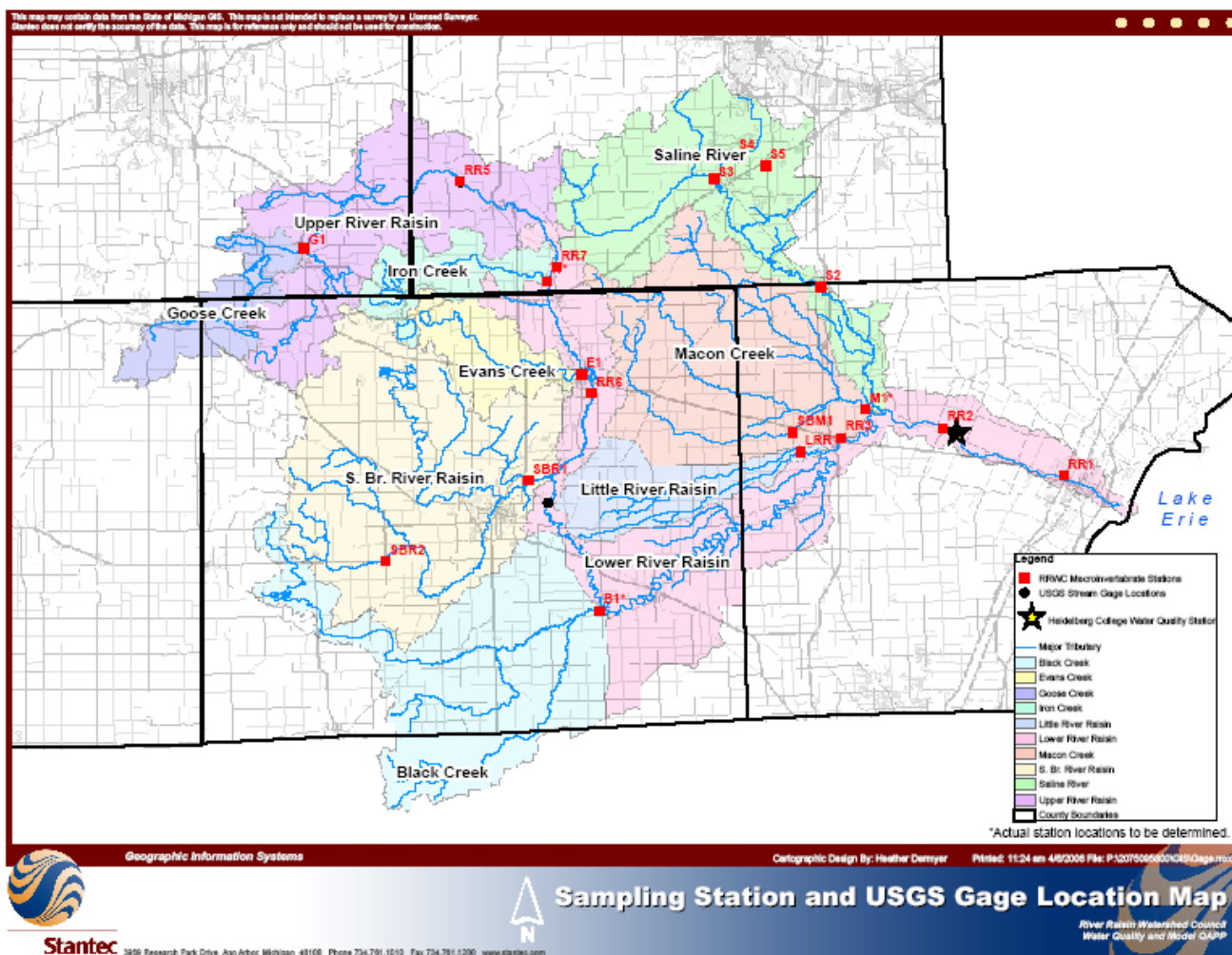


Figure 1. Proposed sampling sites

2.2 Stage and Flow

We will locate a staff gage at each site. The actual gage material will vary. Currently, fourteen of the twenty sites are permanent Adopt-A-Stream macroinvertebrate sampling sites; at these fourteen sites we hope to locate a permanent staff gage composed of a graduated gage plate affixed to a sign post and driven into the stream bed. We anticipate installation of these gages will take the entire two year project period. As an alternative to this kind of installation, we will affix a permanent mark (e.g., pin, nail, scrape) at crossing structures (e.g., culverts, bridges, etc.) and measure down to the water's surface from the mark as a substitute stage measurement. This stage measurement will be tied into two cross-sections that will be shot approximately 200-ft to 300-ft upstream and downstream of the crossing to create a total distance between the sections of 400-ft to 600-ft. For those sites that start with the alternative gage and later receive a staff gage, a relationship between the alternative gage, the cross-sections and the staff gage will be created so that all historical data can be converted to a consistent staff gage reading. The staff gages will be read each time a site is visited, both during water quality and macroinvertebrate sampling.

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Using bed slope between the sections, water depth, an engineer's estimate of channel and overbank Mannings n, the Mannings equation will be used to estimate average cross-section velocity and flow for each stage measurement. During water quality monitoring, the sampling team will use a flow meter to estimate the average cross-section velocity. These velocity measurements will be used to validate the Mannings n estimate. If, over time, the average velocity measurements significantly diverge from the Mannings n estimate, the cross-sections will be re-shot and estimates revised.

2.3 Data Analysis and Interpretation

The existing data collected for this project, including topography, land use/land cover, soils, hydrology, and water quality will be used to compile and calibrate the SWAT model. The calibrated SWAT model will then be used to run various BMP scenarios in order to prioritize water quality improvements for the watershed. The synoptic water quality data (including flow measurements) will be used to help rank subwatershed water quality problems. The water quality data will be compared to the calibrated SWAT model output but not necessarily used to alter model set-up.

2.3.1 Synoptic Water Quality and Flow Data Analysis

The synoptic survey flow and water quality data will be plotted and mean, median, and variance calculated by station. Loads and concentrations will be compared among all stations for a relative ranking of concentration and load priorities. If feasible, a relationship between turbidity and solids will be established by comparing turbidity samples and Total Suspended Solids (TSS) at the Heidelberg site.

Wet weather data will be parsed by rainfall in the sample site subwatershed in the preceeding 24 hours. The time between peak rainfall in the preceeding 24 hours and sample collection will be compared to theoretical time of concentration at the sample point. This metric represents the theoretical location of the sample grab along the subwatershed's rainfall – runoff response hydrograph and will be used to further partition wet weather data for comparison among subwatersheds. The idea here is to estimate the timing of the sample grab to theoretical peak flow in the receiving water.

The concentration and load data for nutrients and TSS will also be compared to model results and to the Heidelberg site long term data. The concentration and load data will be plotted as cumulative distributions and as box and whisker plots.

2.3.2 SWAT Model Analysis

Stantec will prepare a list outlining all data relevant to the model, which includes orthophotography, parcels, existing and future land use plans, past watershed restoration activities, known invasive species locations, recreation map, areas of concern, dam locations, bridge crossings, crop information, and other data deemed to be appropriate. Stantec will collect data from MDEQ, UM, Lenawee County, Monroe

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County, Washtenaw County, Jackson County, Hillsdale County and Fulton County OH. The RRWC and Jill Kelley will interview all local municipalities, townships, and villages to collect other detailed GIS data for integration into the model. Data include:

- Elevation map - USGS National Elevation Dataset, 30 m resolution grid
- Stream channel network – USGS National Hydrologic Data, medium resolution
- Land use/Land cover – National Land Cover Database, 1992, 30 m resolution grid
- Soil type – NRCS Soil Survey Geographic Database, 30 m resolution grid
- Weather data – NOAA Weather Station Network, current weather records
- Point source dischargers – EPA Permit Compliance System sites and loadings (loading data will likely need to be augmented by contacting state agencies, municipalities, and or/industries)
- Local Agencies - current and future build out zoning information from local government, reservoir locations and attributes, agricultural practices in various areas of watershed (such as crop rotations, fertilizer application rates and timing, irrigation practices, tillage operations, etc)
- Raisin River Watershed Hydrologic Study dated 2/17/2006 by David Fongers, MDEQ

This background data will then be integrated into the SWAT model. Lenawee, Monroe, Jackson, Washtenaw and Hillsdale Counties will be contacted to obtain 30-meter resolution Digital Elevation Model (DEM) datasets. The resulting grid file will be utilized by ArcGIS Spatial Analyst to delineate approximately 25 subwatersheds. Land use classes and soil types will be overlaid to define the Hydrologic Response Units (HRUs) for each of the 25 subwatersheds for the SWAT mode. It is proposed that an average of four (4) HRUs will be developed for each subwatershed, resulting in no more than 100 HRUs.

Weather data (daily precipitation, daily maximum and minimum temperatures) from stations in and around the Raisin River watershed will be obtained from National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center and the Southeastern Michigan Council of Government (SEMCOG). It is our understanding that approximately 50 stations currently exist within the watershed. Each subwatershed will be assigned a representative station. The historical duration of rain gage operation will be used to determine the time period for modeling calibration. SWAT is not an event-based model such as AgNPS, but rather a continuous model, which runs at a daily time step and can give daily, monthly, or annual load estimates. The RRWC will assist in downloading the datasets monthly. Stantec will design Excel templates which will perform QAQC and reformat the data into SWAT weather input files.

A database within the BASINS model (the Permit Compliance System) obtains the annual point source flow and nutrient loading data. This database will be examined to determine whether loading data from point sources are available for all 25 subwatersheds for the entire time period of the monitoring. When available, average values of all data from previous years will be used.

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Other accessible data will be incorporated into the SWAT model, including dam, bridge, and pond locations and agricultural attributes (crop rotations, timing and types of tillage, fertilizer and atrazine applications and rates). Up to five agricultural categories will be developed which will group common attributes over the entire watershed.

Calibration will take into account three USGS gage stations and Heidelberg College Water Quality sediment and nutrient data. In addition, volunteers will collect additional information for comparison to the USGS and Heidelberg data. Graphs of data output compared to calibrated SWAT levels will be generated. An R^2 value will be calculated to estimate overall accuracy of the calibration.

SWAT output will display the annual loads of solids, nitrogen and phosphorus for each subwatershed within the Raisin River watershed. These values will be represent average annual values for the time period determined by the SWAT model simulation. Values will be used as baseline loading conditions for future BMP scenario management. Any increasing or decreasing trends can be identified through the graphical GIS interface. The subwatersheds will be prioritized using this baseline data.

The Project Team and the watershed technical committee will work together to recommend improvements for the River Raisin on a subwatershed level. Up to three BMP watershed-wide simulation scenarios will be built for each subwatershed within the SWAT model to examine their effectiveness. Strategies for achieving load reductions will also be modeled. If deemed appropriate, cost estimations and timelines will be developed and integrated in a Watershed Management Plan. Overall model findings, conclusions, assumptions and improvements will be documented for future reference and use by the RRWC, the MDEQ, and the public.

3.0 Data Acquisition

3.1 Field Sampling Process and Methods

The water quality sampling will be conducted by University of Michigan graduate students under the supervision of Dr. David Allan of the School of Natural Resources and Environment. All students will visit the sampling sites before sampling to familiarize themselves with the site, access, and any safety concerns. All sampling will be conducted between dawn and dusk.

Water samples will be collected mid-channel with a chemically clean bucket and immediately processed into designated tubes for nutrient analyses and total suspended matter (TSM). Samples for dissolved nutrients (nitrate and phosphate) will be filtered through a 0.2 micron nylon filter into polypropylene tubes and later frozen until analyzed. Samples for total phosphorus and total nitrogen will be measured out in a clean BD plastic syringe and dispensed into acid-cleaned pyrex tubes. The remaining water will be returned to the UM laboratory in clean polypropylene bottles to use for

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determining TSM. Samples will be placed on ice and in the dark during transport from the field to the laboratory.

Additionally, water temperature, dissolved oxygen (DO), alkalinity, pH, total dissolved solids (TDS), and turbidity will be measured in the field directly according to Standard Operating Procedures (SOPs, Appendix B). A YSI dissolved oxygen meter will be used to measure both temperature and DO. Alkalinity will be measured as acid neutralizing capacity (ANC) using a Hach ANC titration kit. Hanna probes will be used to measure pH and TDS. Turbidity will be assessed using a HF Scientific Turbidimeter.

All sampling equipment and containers will be cleaned and meter operation checked before going into the field. All sites will be clearly marked and all samplers will be shown the precise location for taking each sample. All field meters will be calibrated per manufacturer recommendations. All sampling containers will be clean and pre-labeled.

E. coli samples will be taken by plunging the sample bottle neck down below the water surface and then turning it upright into the flow. Flow stage will be recorded at each sampling site. The sampling team will also construct two transects to determine mean flow velocity and total flow volume using a flow meter.

Within 24 hours, the sampling team will transport all the *E. coli* samples taken up to that point to one of the cooperating laboratories for analysis. These samples will be transported on ice in coolers.

The sampling team will be comprised of two individuals. For the dry weather sampling each sampling period will last for two to three days. For wet weather, two teams of two individuals will be used to sample all 24 sites in one day.

3.2 Analytical Methods

Nutrient concentrations will be analyzed in the UM laboratory using standard automated colorimetric techniques on a Technicon auto analyzer II (APHA 1990) as detailed in the laboratory manual of Davis and Simmons (1979). Nitrate plus nitrite will be measured using the cadmium reduction method. Soluble reactive phosphorus (SRP) will be determined by the ascorbic acid method. Total phosphorus will be determined by an oxidative digestion with potassium persulfate, followed by analysis as SRP. Total nitrogen will be determined by an oxidative digestion with potassium persulfate, followed by analysis as nitrate (APHA 1998). Total suspended matter (TSM) will be determined gravimetrically. Samples will be filtered through a rinsed, dried and pre-weighed Whatman GFC 47 mm filter until nearly clogged (typically between 300–900 mL), and the volume recorded. Filters will then be dried at 60°C for 48 hours and reweighed. TSM will be calculated as the difference between the two weights divided by the volume filtered.

Samples will be analyzed for *E. coli* by one of the cooperating laboratories listed in Table 1.

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Parameters, associated analyses, ranges, method detection limits (MDLs) and storage requirements are summarized in Table 3.

3.3 Quality Control

Blind field duplicates will be collected and analyzed for water samples to check the precision or reproducibility of sampling and analytical procedures. Blind field duplicates are defined as two separate samples collected at a single location and labeled with separate identification codes so that the laboratory will not be able to identify the samples as duplicates. The frequency of duplicate collection will be one duplicate per every 10 samples collected or at least one per event. The duplicate samples will be analyzed for the same parameters at the laboratory.

All samples that change ownership for analysis will be accompanied by a chain of custody (COC) sheet (Appendix C). Labels will be affixed to each sample. Sampling sheets will be prepared for each site for each survey (Appendix A). These sheets will be kept in a 3-ring binder in the UM laboratory for three years.

All analysis equipment will be calibrated before each round of sampling. Calibration will include adjusting equipment response to appropriate standards. Sample spike recoveries will be conducted at least once per each survey for each parameter, as feasible. Each analyst will be required to analyze samples of known concentrations at the beginning of the project to evaluate their performance.

This project will use field analytical equipment to measure water temperature, dissolved oxygen (DO), alkalinity, pH, total dissolved solids (TDS), and turbidity. Preventive maintenance procedures for the equipment will follow manufacturer instructions and equipment operation and maintenance procedures presented in Appendix D.

Table 3. Summary of Water Quality Test Parameters

Parameter	Units	Method	Accuracy	Storage
Temperature	Celsius	YSI 58 Dissolved Oxygen Meter	+/- 0.3 °C	n/a
pH	n/a	HI 98127 Portable Probe	+/- 0.1	n/a
Turbidity	NTU	HF Scientific DRT-15CE Turbidimeter	+/- 1%	n/a
Total Dissolved Solids	µS	HI 98311 Portable Probe	+/- 2%	n/a
Dissolved Oxygen	mg/L	YSI 58 Dissolved Oxygen Meter	+/- 0.03 mg/L	n/a
Acid Neutralizing Capacity	mg/L CaCO ₃	Hach Alkalinity Method 8203	n/a	n/a
Soluble Reactive Phosphorous	µg/L	APHA Meth. 4500-P-F	+/- 0.6 ug/L	filter/0°C
Total Phosphorous	µg/L	APHA Meth 4500-P-B3	+/- 1.0 ug/L	dark/4°C
Nitrate	mg/L	APHA Meth. 4500-NO ₃ -F	+/- 0.02 mg/L	filter/0°C
Total Nitrogen	mg/L	APHA Meth. 4500-N-C	+/- 0.06 mg/L	dark/4°C
Total Suspended Matter	mg/L	APHA Meth. 2540-D	+/- 2.0 mg/L	dark/0°C
<i>Escherichia coli</i>	count/100 mL	Std. Meth. 9222	most probable no.	4°C

4.0 Assessment and Oversight

4.1 Assessments and Response Actions

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The hydrologic and water quality data collected in the field will undergo several levels of data checking. The first assessment will be performed by Dr. Allan, immediately following the sampling events. All data will be entered into an EXCEL database and plotted by station, date, and sampling event to compare relative concentrations and identify trends. Data sheets and chain of custody forms will be checked for consistency and any missing data such as date, time, or sample IDs.

Standard statistics will be calculated including mean and variance. Cohen's method of maximum likelihood estimators will be used to derive mean and variance estimates for censored (values below detection) data sets (Gilbert 1987). Comparison to historical data sets (e.g. Heidelberg Water Quality Laboratory data), best professional judgment, and data trends from the collected data will be used to assess the possible significance of outliers.

Concentration data will be paired with flow data to develop load estimates for the sampling. This data will be compared by Chris Rybak and Scott Dierks for consistency. Questionable data will be corrected with an appropriate statistical technique, substituted with an appropriate justification, or excluded from further analysis.

4.2 Reports

The water quality monitoring and the SWAT modeling results will be reported as chapters or sub-chapters of the River Raisin Watershed Management Plan. These reports will include a summary of data collection, QAQC procedures, results, analysis, and interpretation. These chapters will be available both in hard copy and as PDF files. The results will be reported in draft form for MDEQ review and comment.

5.0 Data Validation and Usability

Data from USGS gage stations, Heidelberg College water quality monitoring station, and the NOAA and SEMCOG rain stations undergo independent verification at their respective collecting organization. JFNew will organize and compare these data sets for consistency, but will not perform extensive verification unless inconsistencies are found.

The water quality data collected for the synoptic surveys will be verified through a standard set of QAQC measures. All samples that change ownership for analysis will be accompanied by a chain of custody (COC) sheet (Appendix B). Sampling labels will be affixed to each sample. Each sampling team will be composed of at least two individuals. Both individuals will be responsible for checking consistency between the sample labels and COC.

Sampling sheets will be prepared for each site for each survey (Appendix B). These sheets will identify date, time, sampler initials, weather summary, site location, number and volume of samples, sample IDs, and field observations and measurements. These sheets will be kept in a 3-ring binder at the UM laboratory for three years.

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6.0 References

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Appendix A.

**RIVER RAISIN WATER QUALITY MONITORING
DATA COLLECTION FORM**

General Information

Sampling Site ID: _____ Cross Street: _____

Sample collectors' initials: _____ Date: _____ Time: _____

WEATHER CONDITIONS	Now	Past 24 hours	Has there been a heavy rain in the last 7 days? <input type="checkbox"/> Yes <input type="checkbox"/> No
	<input type="checkbox"/> storm (heavy rain)	<input type="checkbox"/>	<input type="checkbox"/> Air Temperature _____ °C
	<input type="checkbox"/> rain (steady rain)	<input type="checkbox"/>	<input type="checkbox"/> Other _____
	<input type="checkbox"/> showers (intermittent)	<input type="checkbox"/>	
	____% <input type="checkbox"/> %cloud cover	<input type="checkbox"/> _____%	
<input type="checkbox"/> clear/sunny	<input type="checkbox"/>		

Gage Reading

Initial Reading: _____ ft Time: _____

Final Reading: _____ ft Time: _____

Water Quality Data

pH: _____

Turbidity: _____ NTU

TDS: _____ μS

Temperature: _____ °C

DO: _____ mg/L

ANC: _____ mg/L CaCO₃

SAMPLE

Time	TRACKING NUMBERS					
	SRP	TP	Nitrate	TN	TSM	<i>E. coli</i>

BLIND DUPLICATE

Time	Tracking Numbers

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VELOCITY

Transect 1

	Depth (cm)	Velocity 0.6 (ft/s)
Point 1		
Point 2		
Point 3		

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Appendix B.

STANDARD OPERATING PROCEDURES

Pre-Sampling Procedures:

24-72 hours prior to event

- Identify potential event on radar images from weather websites: <http://www.weather.com>, <http://www.intellicast.com>, <http://iwin.nws.noaa.gov>.
- Make at least 25 copies of the Field datasheet (Appendix A) on waterproof paper.
- Make at least 25 copies of the Chain-of-Custody Form (See Appendix B) on waterproof paper.
- Assemble and label 50 sterilized bottles for *E. coli* analysis, 240 polypropylene bottles, and 96 acid-cleaned pyrex tubes.

2-24 hours prior to event

- Continue to monitor potential event on weather websites.
- Call Adrian WTP (517.263.0923, Shane Horn) to alert them of potential sampling event. Provide estimate of initial arrival time and delivery of first set of samples.
- Calibrate all meters (Appendix D).

2-0 hours prior to event

- Make final decision on event/sampling status.
- Double check equipment list (Appendix E).
- View radar image of weather event.
- Prepare trip blank (deionized water) and record tracking number.
- Buy ice and fill coolers. The following stores are open 24 hours: Kroger (Plymouth at Nixon), Busch's (Green at Plymouth), and Ann Arbor Shell (Washtenaw at Huron Parkway). Alternatively use any Speedway gas station.
- Wet weather only: arrive at first sampling site before first flush (before runoff is visible on pavement).

Sampling Procedures:

The sampling tasks will be done simultaneously by two team members. A Field Datasheet (Appendix A) will be used by each team. Task descriptions are as follows:

Team member 1:

Grab sample

- Rinse bucket at least 3 times with sample water.
- Use bucket to grab sample from center of stream. Do NOT disturb bottom sediments. Sample depth depends on following criteria:
 - If water depth < 1.5 ft, grab at 1/3 total water depth measured from surface.
 - If water depth > 1.5 ft, grab at 1 ft below surface.
- Measure 100 mL water in graduated cylinder and pour into beaker for ANC titration. Add bromocresol methyl-green red indicator packet. Titrate to endpoint with 0.06 H₂SO₄. Record ANC (mg/L CaCO₃) on datasheet.

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- Pour sample into bucket:
 - Make sure that bucket is brought to same temperature as sample (~5-minute holding time).
 - Fill bucket to an appropriate depth so that probe tips will be completely immersed.
 - Keep sample out of the rain/sun during measurements (use tarp/umbrella).
- Use meters to take following measurements in order, ensuring equilibration before recording:
 - pH
 - TDS (μS)
 - DO (mg/L) and temperature (Celsius): Be sure to gently stir probe in sample.
 - Turbidity (NTU)
- Rinse probes before and after each measurement with deionized water, EXCEPT the pH meter must be rinsed with tap water.
- Record time of measurements (in military time).
- Discard water downstream of sampling point or on the floodplain.

Team member 2:

General information

- Enter collectors' initials, date, and current weather conditions on field data sheet beforehand if possible.
- Label bottles with station ID, date, and time.
- Enter any other important observations/pictures taken on field data sheet.

Stage measurement (initial)

- Record water level from gage (hundredths of feet).
- Record time taken (in military time).

Laboratory samples

- Use bucket/dipper to grab sample from center of stream (using same depth and rinsing criteria as listed above).
- Fill eight labeled polypropylene bottles with water samples. Fill four acid-cleaned pyrex tubes using a clean BD plastic syringe. Place all samples in ice chest at 4 °C.
- Enter tracking numbers on datasheet.
- For duplicate samples, fill two more bottles and record station ID and tracking numbers in appropriate duplicate section.

Stage measurement (final)

- Record water level from gage a second time.
- Record time taken (in military time).

Both team members:

Flow Measurements

- Measure depth and flow velocity at 0.60 depth from surface at three points across channel width.

Before drop-off to coordinating lab

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- Complete Chain-of-Custody Form for *E. coli* samples (Appendix C). Request analysis results in both faxed and mailed hardcopy formats. Note: no more than four hours should elapse from time of first grab sample and handoff of samples to coordinating lab.
- Call Adrian WTP to notify of delivery.

Post-Sampling Procedures:

- Clean all probes.
- Deliver one water sample from each sampling site to coordinating lab for *E. coli* analysis.

CHAIN OF CUSTODY

Point of origin:



DANA BUILDING
ANN ARBOR, MICHIGAN 48109-1115
PHONE: (734) 764-6553
E-MAIL: DALLAN@UMICH.EDU

Saline Pollution Control Facility
100 North Harris St
Saline, MI 48176
(734) 429-4907

Tecumseh Wastewater Treatment Plant
710 East Chicago Blvd
Tecumseh, MI 49286
(517) 423-6292

Adrian Water Treatment Plant
815 Bent Oak Ave.
Adrian, MI 49221
(517) 263-2161

Receiving laboratory (circle one):

SAMPLER'S PRINTED NAME				SAMPLER'S SIGNATURE					ANALYTICAL PARAMETERS						COMMENTS Material Preserved / Weight NOT Sampled/Retained etc.	
ITEM #	SAMPLE ID	DATE SAMPLED	TIME SAMPLED	AIR	SOLID	FLUID	VOLUME	SAMPLE DESCRIPTION	NO. OF CONTAINERS							
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
Relinquished By		Date	Time	Received By		Date	Time									
Relinquished By		Date	Time	Received By		Date	Time							FOR LAB USE ONLY		
Relinquished By		Date	Time	Received By		Date	Time							Wet samples preserved <input type="checkbox"/> in field <input type="checkbox"/> in lab <input type="checkbox"/> IGA		
														Wet samples filtered <input type="checkbox"/> in field <input type="checkbox"/> in lab <input type="checkbox"/> IGA		
														Time of sample: _____ hr On/Off line? _____		
TAT: Standard <input type="checkbox"/>				RUSH: Next BD <input type="checkbox"/> 3rd BD <input type="checkbox"/> 3rd SD <input type="checkbox"/>				Comments: _____								
												Note: RUSH requests will incur surcharges!				
Distribution: Wet and Tare - Lab, Pkg - Field												See reverse side for Laboratory Terms and Conditions of service				

Appendix D.

MANUFACTURER INSTRUCTIONS FOR EQUIPMENT CALIBRATION QUALITY CONTROL

4.2 TURNING THE INSTRUMENT ON

The YSI 58 may be used in a vertical, horizontal or tilted position. It may be carried or moved during use without affecting its accuracy or stability of measurement.

1. Connect the prepared probe to the PROBE receptacle and screw the retaining ring finger tight.
2. Zero the instrument. Set the function switch to **ZERO** and adjust the display to read **00.0** with the **O₂ ZERO** control.
3. If using a stirrer, connect it now. Check the stirrer battery condition by turning the **STIRRER** switch to its spring-loaded **BATT CHK** position. The warning **LOBAT** will show on the display when approximately 5 hours of battery life remain.
4. Wait at least 15 minutes for the probe to stabilize. A wait is necessary whenever the meter has been OFF or the probe has been disconnected.

4.3 CALIBRATION

To calibrate the YSI 58, the function switch is set to the percent saturation mode with the probe in moist air; then the **O₂ CALIB** control is adjusted to obtain a meter reading corresponding to the calibration value for the local altitude. Charts for quickly determining the calibration values can be found in Appendix F, Calibration Values Table.

This simple procedure accurately calibrates the meter for readings in both the mg/L and the percent saturation modes. The instrument may be switched from one mode to the other without losing its calibration. Other methods are also possible and are discussed in greater detail in Section 4.3, Calibration.

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Calibration consists of exposing the probe to a known oxygen concentration such as air at 100% relative humidity or water of a known oxygen content, and then adjusting the **O₂ CALIB** control so the display shows a reading that matches the O₂ concentration of the known sample.

In the discussion of calibration below instructions for Air Calibration are given for calibrating in the % air saturation mode, while instructions for Air Saturated Water Calibration are given for calibrating in the mg/L mode. Take note that either calibration technique can be performed in either mode. Use of the percent air saturation mode is normally easier since the instrument automatically compensates for temperature variation in that mode. The operator may nevertheless elect to calibrate in the mg/L mode if he intends to make measurements in that mode, since doing so will eliminate any possible mode-to-mode error. See final **NOTE** under both Air Calibration and Air Saturated Water Calibration.

4.3.1 AIR CALIBRATION

Air Calibration is the quickest and by far the simplest calibration technique. Experience has shown that it is reliable and is recommended for the YSI 58. Air Calibrate the YSI 58, with any field probe as follows:

1. Set the function switch to **% Mode**.
2. To calibrate the probe, place a moist sponge or a piece of cloth in the plastic calibration bottle. Loosen the bottle lid about ½ turn and slip the bottle over the probe guard up to the body. Place the probe in a protected location where temperature is not changing, or wrap it in a cloth or other insulator.
3. The BOD probes can be placed in a BOD bottle containing about one inch of water to provide a 100% relative humidity calibration environment.
4. Remember that the highest accuracy of measurement is achieved when the probe is zeroed and calibrated at a temperature as close as possible to the temperature of the sample to be measured.
5. Set the function switch to **ZERO** and readjust the display to read **0.00**. Switch back to percent air saturation mode.
6. Determine the local altitude or the “true” atmospheric pressure. Using the pressure/altitude chart, determine the correct **CALIB VALUE** for your pressure or altitude

Note: True atmospheric pressure is as read on a mercury barometer. Weather Bureau reporting of atmospheric pressure is corrected to sea level.

7. When the display reading has stabilized, unlock the **O₂ CALIB** control locking ring and adjust the display to the **CALIB VALUE** indicated in the pressure/altitude chart in Appendix F. Relock the locking ring to prevent inadvertent changes.

NOTE: The oxygen content of air is affected by water vapor content. The use of air at 100% relative humidity assures proper calibration. Moreover, air at less than 100% relative humidity can

cause evaporation of moisture from the probe's temperature sensor, producing a local cooling effect. Errors of up to 8% can result from calibrating in dry air.

NOTE: Should the user elect to air calibrate in the mg/L mode, Air Saturated Water Calibration steps 2-5 should be followed.



Alkalinity

Method 8203

Phenolphthalein and Total using Sulfuric Acid Method

Digital Titrator

(10 to 4000 mg/L as CaCO₃)

Scope and Application: For water, wastewater, and seawater



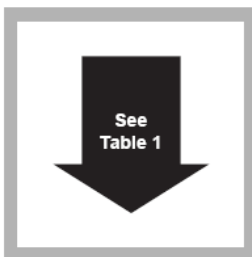
Tips and Techniques

- For added convenience when stirring, use the TitraStir® apparatus (Cat. No. 19400-00, -10).
- Four drops of Phenolphthalein Indicator Solution (Cat. No. 162-32) may be substituted for the Phenolphthalein Indicator Powder Pillow.
- Four drops of Bromcresol Green-Methyl Red Indicator Solution (Cat. No. 23292-32) may be substituted for the Bromcresol Green-Methyl Red Indicator Powder Pillow.
- meq/L Alkalinity = mg/L as CaCO₃ ÷ 50

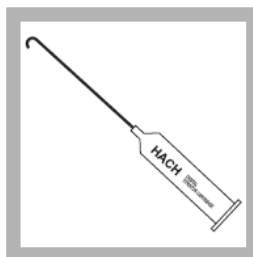


Digital Titrator

Method 8203



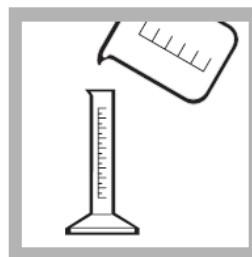
1. Select the sample volume and Sulfuric Acid (H₂SO₄) Titration Cartridge that correspond to the expected alkalinity concentration as mg/L calcium carbonate (CaCO₃) from *Table 1*.



2. Insert a clean delivery tube into the titration cartridge. Attach the cartridge to the titrator body.



3. Turn the delivery knob to eject a few drops of titrant. Reset the counter to zero and wipe the tip.



4. Use a graduated cylinder or pipet to measure the sample volume from *Table 1*. Transfer the sample into a clean, 250-mL Erlenmeyer flask. Dilute to the 100-mL mark with deionized water, if necessary.



5. Add the contents of one Phenolphthalein Indicator Powder Pillow and swirl to mix.



6. If the solution turns pink, titrate to a colorless end point. Place the delivery tube tip into the solution and swirl the flask while titrating with sulfuric acid. Record the number of digits required.

If the solution is colorless before titrating with Sulfuric acid, the Phenolphthalein (P) alkalinity is zero. Proceed to step 8.



7. Calculate:
Digits Required X
Digit Multiplier =
mg/L as CaCO₃ P Alkalinity



8. Add the contents of one Bromcresol Green-Methyl Red Indicator Powder Pillow to the flask. Swirl to mix.



9. Continue the titration with sulfuric acid to a light pink (pH 4.5) color as required by sample composition. Record the number of digits required.

Note: A pH meter may be used to titrate to a specific pH as required by sample composition. See Table 2.



10. Calculate:
Digits Required X
Digit Multiplier =
mg/L as CaCO₃ Total (T or M)
Alkalinity

Carbonate, bicarbonate, and hydroxide concentrations may be expressed individually using the relationships shown in Table 3.

HI 98127 pH Meter

SPECIFICATIONS

Range	pH -2.00 to 14.00 pH (HI 98127) -2.00 to 14.00 pH (HI 98128)
Resolution	pH 0.1 pH (HI 98127) 0.01 pH (HI 98128)
Accuracy	pH ±0.1 pH (HI 98127) (NOMINAL) ±0.03 pH (HI 98128)
Typical	pH ±0.3% / ±1% ENC Deviation ±0.02 pH (HI 98128)
Temp. Compensation	Automatic
Environment	-5 to 50°C (23 to 122°F); RH100%
Calibration	1 or 2 points with 2 sets of recognized 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 alk. (R25, typical 300 hours)
Auto-off	After 6 minutes
Dimensions	163 x 40 x 25 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 μ /MODE button until the LCD lights up. All the used segments on the LCD will be visible for 1 second (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 \oplus 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 μ /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 μ /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 SEC 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 μ /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 μ /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

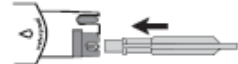
Setup mode allows the selection of temperature unit and pH buffer set.

- To enter the Setup mode, press the μ /MODE button until CAL on the secondary display is replaced by TSMF and the current temperature unit (E.g. TSMF °C). Then:
• For **TEMPERATURE**: Use the SET/HOLD button. After the temperature unit has been selected, press the μ /MODE button to enter the buffer set selection mode; press the μ /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 μ /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 counter-clockwise.



Pull the electrode out by using the other side of the tool.



Insert a new pH electrode following the above instructions in reverse order.

BATTERY REPLACEMENT

The meter display the remaining battery percentage every time it is switched on. When the battery level is below 5%, the BATT symbol on the bottom left of the LCD lights up to indicate a low battery condition. The battery 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 (BEP) 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.

HI 98311 TDS Meter

OPERATIONAL GUIDE

To turn the meter on and to check battery status.
Press and hold the ψ /MODE button for 2-3 seconds. All the usd segments on the LCD will be visible for a few seconds, followed by a percent indication of the remaining battery life (E.g. % 100 BATT).

Taking measurement.

Submerge the probe in the solution to be tested. Use plastic beakers to minimize any electromagnetic interference.

Select either EC or TDS mode with the SET/HOLD button.

The measurements should be taken when the stability symbol \odot on the top left of the LCD disappears.

The EC (or TDS) value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.



To change the temperature unit.

To change the temperature unit (from °C to °F), from measurement mode, press and hold the ψ /MODE button until TEMP and the current temperature unit are displayed on the lower portion of the LCD (E.g. TEMP °C).

Use the SET/HOLD button to change the temperature unit, and then press the ψ /MODE button twice to return to the normal measuring mode.

To freeze the display.

Press the SET/HOLD button for 2-3 seconds until HOLD appears on the secondary display.

Press either button to return to the normal measuring mode.



To turn the meter off.

Press the ψ /MODE button while in normal measuring mode. OFF will appear on the lower part of the display. Release the button.

Notes:

- Before taking any measurement make sure the meter has been calibrated.
- 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:

- The EC/TDS probe is replaced.
- After testing aggressive chemicals.
- Where high accuracy is required.
- At least once a month.

To change the EC/TDS conversion factor (CONV) and the temperature compensation coefficient β (SET).

- From measurement mode, press and hold the ψ /MODE button until TEMP and the current temperature unit are displayed on the lower LCD (E.g. TEMP °C).
- Press the ψ /MODE button again to show the current conversion factor (E.g. 0.50 CONV).
- Press the SET/HOLD button to change the conversion factor.
- Press the ψ /MODE button to show the current temperature compensation coefficient β (E.g. 2.1 SET).
- Press the SET/HOLD button to change the temperature compensation coefficient β .
- Press the ψ /MODE button to return to the normal measuring mode.

Calibration procedure

- From measurement mode, press and hold the ψ /MODE button until CAL is displayed on the lower LCD.
- Release the button and immerse the probe in the proper calibration solution: HI70031 (1413 μ S/cm) for HI98311 and HI70030 (12.88 mS/cm) for HI98312.
- Once the calibration has been automatically performed, the LCD will display OK for 1 second and the meter will return to normal measurement mode.
- Since there is a known relationship between EC and TDS readings, it is not necessary to calibrate the meter in TDS. If the EC/TDS conversion factor is either 0.5 or 0.7, the meter will allow a direct calibration in ppm by using the Hanna calibration solutions listed below.

The CAL symbol on the LCD means that the meter is calibrated.

To reset to the default calibration.

To clear a previous calibration, press the MODE button after entering the calibration mode. The lower LCD will display ESC for 1 second and the meter will return to normal measurement mode. The CAL symbol on the LCD will disappear. The meter will be reset to the default calibration.

PROBE MAINTENANCE

The EC/TDS probe can be easily replaced by using the supplied tool (HI 73128). Insert the tool into the probe cavity as shown below.



Rotate the probe counter-clockwise.



Pull the probe out by using the other side of the tool. Insert a new probe following the above instructions in reverse order.



BATTERY REPLACEMENT

The meter displays the remaining battery percentage every time it is switched on. When the battery level is below 5%, the BATT symbol on the bottom left of the LCD lights up to indicate a low battery condition. The battery 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 (BEP) 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 gaskets are properly seated in place, and tighten the screws to ensure a watertight seal.

ACCESSORIES

- HI 73311 Replaceable EC/TDS probe
- HI 73128 Probe removal tool
- HI 70030F 12.88 mS/cm @25°C calibration solution, 20 ml sachet (25 pcs)
- HI 70031P 1413 μ S/cm @25°C calibration solution, 20 ml sachet (25 pcs)
- HI 70032P 1382 ppm @25°C calibration solution, 20 ml sachet (25 pcs)
- HI 70038P 6.44 ppt @25°C calibration solution, 20 ml sachet (25 pcs)
- HI 70442P 1500 ppm @25°C calibration solution, 20 ml sachet (25 pcs)

HF Scientific DRT-15CE Turbidimeter

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4.0 OPERATION AND DESCRIPTION

To operate the turbidimeter, it is first necessary to standardize the instrument. Switch to the "10" range and place the Calibration Standard (0.02 NTU) in the optical well.

The EPA recommends that cuvettes used for instrument calibration or sample measurement be indexed. For quick and repeatable indexing of the Calibration Standard, an indexing ring and locator pin are included with this instrument.

When shipped, the white locator pin is installed in the collar ring around the optical well of your turbidimeter. The indexing ring is included in the accessory section of this instrument.

To index your Calibration Standard, slowly rotate the Calibration Standard, at least one complete revolution, while observing the reading, and locate the position of the lowest reading. Without moving the Calibration Standard, install the indexing ring over the ridged cap of the Calibration Standard, install the indexing ring over the ridged cap of the Calibration Standard such that the arrow on the o-ring aligns with the locator pin.

When indexing the Calibration Standard in the future, simply insert the Calibration Standard and rotate it until the arrow on the o-ring faces the locator pin. Please note that this Calibration Standard is only indexed to the turbidimeter for which it was aligned.

To standardize, first index the Calibration Standard as above. Then adjust the Reference Adjust in the appropriate direction to cause the display to read 0.02 NTU. The unit is now ready for use on any range.

To make a measurement of a sample, clean one of the cuvettes and fill it to within approximately 1/2" (12 mm) of the top with the sample to be measured. Place the cap on the cuvette and carefully clean the outside surface of the cuvette with a lint free wiper such as "Kimwipes". Place the sample in the well and take the NTU reading directly from display. Select the appropriate range for best resolution..

If the instrument has been subjected to cold (below 10 degrees Celsius) and then brought indoors, it should be allowed to warm up before use, since condensation may form on the various lenses. Warm up can be aided by leaving the case open and the instrument on for approximately a half hour.

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7.0 CALIBRATION PROCEDURES

7.1 Calibration Standards

7.1.1 PRIMEIME Standard Set (optional) Catalog No. 19071
HF PRIMEIME Standards are recommended and certified by HF scientific. They are traceable to freshly prepared formazin primary standards. These standards are very easy to use off the shelf anytime without preparation making them an ideal turbidity standard. A Certificate of Traceability is available on request to the HF scientific Customer Service Department. HF PRIMEIME Standards may be used for calibration of HF turbidimeters. Order from HF scientific, inc.

NOTE: Do not freeze standards.
Do not leave standards in the measuring well for extended periods.
Do not shake standards.

Each PRIMEIME Standard Kit contains:
-- 0.02 Calibration Standard
-- Certified PRIMEIME Standards 10.00, 100.0, 1000 NTU
Standards are contained in preselected cuvettes with light shield caps.
-- A sturdy storage case

7.1.2 Standard Formazin Solutions
Calibration of this instrument is based on Formazin, a material which is made by polymerization.

Calibration samples may be obtained by diluting Formazin stock suspension using "Turbidity-Free" water. Formazin stock suspension can be prepared by the user (Reference Standard Methods For Examination of Water and Wastewater) or a kit can be purchased from, HF scientific, inc., Catalog No. 50040.

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Appendix E.

EQUIPMENT LIST

Sampling containers:	
	Chemically clean bucket
	Beaker
	240 Pre-labeled polypropylene sample bottles
	50 Pre-labeled sterilized bottles for E. coli analysis
	96 Pre-labeled acid-cleaned pyrex tubes
Equipment cleaning:	
	Deionized water (DIW) both in squirt bottle and extra
	Tap water for rinsing both in squirt bottle and extra
	Paper wipes, paper towels, oil sorbent pads
Sample preservation:	
	Ice with coolers
Field measurement:	
	Clipboard and pencil
	25 Field Data Sheets on waterproof paper
	25 Chain-of-Custody Forms on waterproof paper
	pH meter with instruction manual
	TDS meter with instruction manual
	DO meter with instruction manual
	Turbidimeter with instruction manual
	Measuring tape
	Flow meter
	Meter stick
Safety:	
	Appropriate foot wear, waders
	Rain gear, umbrella
	Tool box: basic tools including graphite lubricant (not oil or WD-40), calculator
	First-aid kit, knife
	List of emergency phone numbers
	Flashlight and spare batteries
	Cellular phone
	Bug spray, sunscreen, hat
General supplies:	
	Business cards, field forms
	Authorization for access to sampling site
	Waterproof pens, markers, pencils
	Garmin GPS unit
	Extra batteries (AA, D)
	Digital Camera