NEW MEXICO ENVIRONMENT DEPARTMENT
SURFACE WATER QUALITY BUREAU

QUALITY ASSURANCE PROJECT PLAN FOR NUTRIENT MONITORING TO DEFINE QUANTITATIVE ENDPOINTS AND RELATIONSHIPS BETWEEN NUTRIENT LEVELS AND RESPONSE VARIABLES IN ORDER TO REFINE NUTRIENT ASSESSMENT PROTOCOLS - PHASE 1

Submitted to:
U.S. Environmental Protection Agency
Region 6

Submitted by:
New Mexico Environment Department
Surface Water Quality Bureau
1190 Saint Francis Drive
Santa Fe, NM 87502

June 9, 2005

Title and Approval Sheet

Project Title: Nutrient Monitoring to Define Quantitative Endpoints and Relationships Between Nutrient Levels and Response Variables in Order to Refine Nutrient Assessment Protocols - Phase 1

New Mexico Environment Department Surface Water Quality Bureau

Program Manager: _____ Date: _____
Lynette Guevara, Staff Manager

Project Manager: _____ Date: _____
Seva Joseph, Environmental Specialist

QA Officer: _____ Date: _____
Stephanie Stringer, Environmental Specialist

United States Environmental Protection Agency Region VI

EPA Quality Assurance Manager: _____ Date: _____
Mike Schaub,

EPA Project Officer: _____ Date: _____
Phillip Crocker, Acting Chief

TABLE OF CONTENTS

LIST OF ACRONYMS 4
SECTION 1 PROJECT MANAGEMENT 5
1.1 Project Definition/ Background 5
1.2 Project/Task Description 6
1.3 Proposed timetable 6
1.4 Data Quality Objectives (DQOs) 7
SECTION 2 DATA GENERATION AND ACQUISITION 8
2.1 Sampling Process Design 8
2.2 Field Measurement and Sampling Procedures 11
2.3 Sample Handling and Custody Requirements 12
2.4 Analytical Methods Requirements 13
2.5 Quality Control Requirements 13
2.6 Instrument/ Equipment Testing, Inspection, and Maintenance Requirements 13
2.7 Instrument Calibration and Frequency 14
2.8 Inspection and Acceptance Requirements for Supplies 14
2.9 Data Acquisition Requirements 14
2.10 Data Management 14
2.11 Assessments and Response Actions 15
2.12 Reports 15
SECTION 3 DATA VALIDATION AND USABILITY 15
3.1 Data Review, Validation and Verification Requirements 15
3.2 Validation and Verification Methods 15
3.3 Reconciliation with Data Quality Objectives 15
REFERENCES 17
APPENDIX A. Data Sheets 19
Nutrient Survey Equipment Checklist 20
Level II Nutrient Survey Form 21
Aquatic Vegetation Evaluation Form 23
Pebble Count Tally Sheet 23
HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS 24
HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS 26
RAPID GEOMORPHIC ASSESSMENT (RGA) FORM 28

LIST OF ACRONYMS

AFDM	Ash free dry mass
APHA	American Public Health Association
CFR	Code of Federal Regulations
cm^2	Square centimeters
CWA	Clean Water Act
DO	Dissolved Oxygen
ft/s	Feet per second
GIS	Geographic Information Systems
GPS	Global Positioning System
mg	Milligram
mg/L	Milligrams per liter
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
ºC	Degrees Celsius
QA	Quality Assurance
QAP	Quality Assurance Program
QAPP	Quality Assurance Project Plan
QC	Quality Control
RBP	Rapid Bioassessment Protocol
RTH	Richest-Targeted Habitat
SCI	Benthic macroinvertebrate stream condition index
SLD	Scientific Laboratory Division
SOP	Standard Operating Procedure
STORET	Storage and Retrieval
SWQB	Surface Water Quality Bureau
TDS	Total dissolved solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

SECTION 1 PROJECT MANAGEMENT

1.1 PROJECT DEFINITION/ BACKGROUND

Excessive nutrients are one of the top three causes of impairment to the nation's waters. The federal Clean Water Action Plan of March 1998 requires that EPA and States develop and implement numeric criteria for nutrients. In January of 2001, EPA recommended that states develop a plan for nutrient criteria development by the end of the year and make substantial progress in this plan by the end of 2004. In January of 2002, Surface Water Quality Bureau (SWQB) submitted a letter to EPA Region 6 stating that development of nutrient criteria would be based on the nutrient assessment protocol. In 2004, SWQB will submit a Nutrient Criteria Development Plan and draft Nutrient Assessment Protocol to EPA for review and comment.

The state of New Mexico has a narrative nutrient criterion which states that "Plant nutrients from other than natural causes shall not be present in concentrations which will produce undesirable aquatic life or result in a dominance of nuisance species in surface waters of the state" (NMAC 2002). This narrative nutrient criterion is challenging to assess, as the relationships between nutrient levels and impairment of designated uses are not defined, and distinguishing nutrients from "other than natural causes" is difficult. To meet this challenge, SWQB developed a nutrient assessment protocol. It was developed for wadeable streams, which represent the majority of assessed surface waters in the state. This protocol was successfully applied and used to develop non-point source Total Maximum Daily Loads (TMDLs) however, it lacked impairment thresholds and quantitative endpoints needed to develop TMDLs with both non-point and point sources. There is a need to define numeric translators for the narrative nutrient criterion. The revised assessment protocol will have quantitative endpoints and will use a weight of evidence approach in order to conduct a robust assessment accounting for diverse lotic systems and dynamic nutrient cycling.

The SWQB does not currently have the data needed to define the relationships between the cause and response variables and impairment thresholds or to test and refine literature threshold values. The four primary nutrient criteria variables suggested by EPA in the Nutrient Criteria Technical Guidance Manual (EPA 2000a) are: water column concentrations of total nitrogen (TN) and total phosphorus (TP) (causal parameters), algal biomass (as chlorophyll *a*), and turbidity or transparency (response parameters). Additional response variables such as dissolved oxygen (DO), pH, plankton and periphyton biomass and community composition, and benthic macroinvertebrate community composition will also be considered. While the SWQB has been monitoring nutrient concentrations for many years, response variables such as plankton and periphyton community composition and biomass and benthic macroinvertebrate community composition have been monitored infrequently. Cause and response variables were rarely monitored concurrently. These types of data are needed to define relationships between causal and response variables, quantitative endpoints, and impairment thresholds. An "effects-based approach" requires the definition of quantitative relationships between the variables.

1.2 PROJECT/TASK DESCRIPTION

Data will be collected and analyzed to refine existing nutrient monitoring and assessment protocols for wadeable streams and the associated numeric translator values for both cause and response variables. A nutrient survey protocol will be developed and a revised nutrient assessment protocol drafted. As a first cut in developing threshold values for wadeable streams, SWQB will conduct data analysis and a literature review. Evan Hornig of the United States Geological Survey (USGS) will conduct analysis of existing nutrient data to define ecoregional TN and TP threshold values. A literature review will be conducted to define potential threshold values for the other variables including: DO, pH, algal biomass, and benthic macroinvertebrate community composition.

These threshold values will be tested and refined with regional data. In order to accomplish this, SWQB will survey 8 to10 wadeable streams reference sites (Table 1) from each of 6 Level III Ecoregions (Omernik 1987). The reference sites will be distributed over different elevations and watershed sizes. In addition to the reference, or best available sites, test sites with suspected nutrient enrichment will be monitored. A nutrient survey will be conducted at each site including measurement of the following variables: 1) periphyton biomass (as benthic chlorophyll *a* concentration and ash free dry mass (AFDM), 2) periphyton community composition, 3) nutrient concentrations (TP, TN, ammonia, and total Kjeldahl nitrogen (TKN)), 4) DO, pH, turbidity, temperature, and conductivity readings and 3-7 days of hourly recordings of these parameters at select sites, 5) benthic macroinvertebrate community composition, and 6) a number of habitat parameters including velocity, canopy cover, width and depth, and pebble counts. Additional site information will be collected to aid in classifying streams and defining reference sites. Classification and site scoring parameters to be added to the dataset include ecoregion, stream order, watershed size, elevation, percent of different land uses, designated use, and watershed geology as well as water quality parameters such as conductivity, pH, and temperature. The data will then be analyzed to test the threshold values, refine waterbody classification, and, where possible, given the limited dataset, define impairment thresholds and adjust threshold values.

1.3 PROPOSED TIMETABLE

Date	**Task**
August 30, 2003	Meeting to plan study and select sites
September 30, 2003	Watershed reconnaissance and site selection
December 31, 2003	Establish monitoring stations
June 31, 2003	Draft of monitoring and assessment protocol
March 1, 2004	Begin monitoring
December 31, 2004	Complete monitoring
April 30, 2005	Process water, algal, and benthic samples
August 31, 2005	Populate database and begin analysis
December 31, 2005	Refine Nutrient Assessment Protocol Based on Findings

1.4 DATA QUALITY OBJECTIVES (DQOS)

The project is intended to produce data to refine the SWQB Nutrient Assessment Protocol for Wadeable Stream by defining a classification system for wadeable streams and developing and testing nutrient translator values for the select nutrient variables. The nutrient variables under consideration are: water column concentrations of TN and TP (causal parameters), periphyton biomass (as chlorophyll *a*), dissolved oxygen, pH, and periphyton and benthic macroinvertebrate community composition (response parameters). The data quality objectives for this project include the following:

1) To collect water quality, habitat, and biological data that are representative of best available wadeable streams from various elevations, watershed sizes, and ecoregions within New Mexico. **Representativeness** will be achieved by selection of sites, training of sampling staff, and adherence to SWQB standard operating procedures (SOPs) and the quality assurance project plan (QAPP). All of the data will be collected and processed in accordance with methods documented in our EPA-approved QAPP (NMED/SWQB 2005) and associated SOPs (NMED/SWQB 2004). Periphyton samples will be collected by compositing samples from 10 locations along a diagonal transect through a riffle in order to better represent the site given the patchy distribution of periphyton (Biggs and Kilroy 2000).

2) To collect data that are comparable. **Comparability** will be achieved through the use of standardized data collection methods and sample handling and analysis. Standardization will be attained by: 1) using standardized field forms (Appendix A), 2) sampling a single habitat type (riffles), 3) utilizing standardized benthic macroinvertebrate, water quality, habitat, and periphyton sampling and processing methods, and 4) ensuring consistent data handling and reporting.

3) To collect data with a high degree of precision. **Precision**, or reproducibility among duplicate observations, will be addressed by collection of duplicate water quality and periphyton biomass samples. The water quality duplicates will be subjected to a thorough QA review with the relative percent difference calculated for each parameter and those that are outside of the control limits flagging as described in the SWQB QAPP Section No. 4 (NMED/SWQB 2005). The QA/QC procedures include the collection and analysis of 10% of water samples as duplicate and blanks, adherence to calibration methods, and taxonomic verification of a subset of periphyton and benthic macroinvertebrate samples as well as a thorough QA review of all site and analytical data, and flagging of all parameter that are outside of the control limits.

   Three to five replicate chlorophyll *a* and AFDM samples will be taken from each reach in order to assess between-reach variability compared to within-reach variability. The signal to noise ratio will be calculated as follows:

$$\frac{\text{Standard deviation between-site}^2}{\text{Standard deviation within-site}^2}$$

The higher the ratio, the better the discrimination between sites. Values over 10 eliminate bias in population estimates (Rosenberg and Resh 1993).

4) To collect data with a high degree of completeness**.** **Completeness** is the percentage of samples that are actually collected compared to the sampling plan that also meet the QA/QC field and laboratory requirements detailed in this QAPP. Completeness will be calculated as:

$$\text{Completeness} = \frac{\text{valid data obtained}}{\text{total data planned}} \times 100$$

The completeness requirement will be to routinely achieve 80 percent completeness.

SECTION 2 DATA GENERATION AND ACQUISITION

2.1 SAMPLING PROCESS DESIGN

SWQB will survey 8 to10 wadeable streams reference sites (Table 1) from each of the following 6 Level III Ecoregions: Southern Rockies, Arizona/New Mexico Plateau, Arizona/New Mexico mountains, Chihuahuan Desert, Western High Plains, and the Southwestern Tablelands. The Madrean Archipelago will not be surveyed during this study due to its small size and scarcity of perennial streams. Best available sites that are distributed over different elevations and watershed sizes were selected. Reference sites were selected in two ways: 1) from sites that were assigned a score for benthic macroinvertebrate stream condition index (SCI) development and 2) by a consensus of best professional judgment of scientists familiar with the region. Part of the development of the benthic macroinvertebrate SCI included assigning scores to all sites based on land uses, Clean Water Act §303(d) listings, habitat scores, flow alteration, and best professional judgment in order to define reference sites and a gradient of impairment. These scores were also used to select reference sites for monitoring nutrient variables. In addition to the reference sites, select test sites with suspected nutrient enrichment will be monitored (Table 2).

Table 1. Nutrient reference sites

Site ID	Location	Latitude	Longitude	Size (mi^2)	Elevation (ft)	Omernik Level III Ecoregion
50Gallin131.8	Gallinas R. at National Forest Boundary	35.70293	-105.43083	21.0	7480	Southern Rockies
05Rayado033.8	Rayado Creek at Philmont near USGS gage	36.37222	-104.96944	59.1	6795	Southern Rockies
29RChama143.8	Rio Chama 2mi below La Puente Gage	36.66726	-106.66360	482.0	7136	Southern Rockies
50PecosR803.7	Pecos River 400m above Willow Creek	35.76290	-105.67006	216.0	7822	Southern Rockies
29RBrazo010.1	Rio Brazos 1 mile above Corkin's Lodge	36.73722	-106.42611	114.3	7992	Southern Rockies
29RGalli045.1	Rio Gallina @FR 76	36.17479	-106.84760	5.6	7920	Southern Rockies
50RioMor000.3	Rio Mora at USGS Gage above campground	35.77723	-105.65750	53.2	7926	Southern Rockies
28RSanBa017.9	Rio Santa Barbara at S. B. Campground	36.08540	-105.60880	33.4	8868	Southern Rockies
30SantaF057.4	Santa Fe River above McClure reservoirs	35.68861	-105.82222	10.6	7930	Southern Rockies
28RGRanc013.1	Rio Grande del Rancho at gage near Talpa	36.29778	-105.58194	84.0	7264	Arizona/New Mexico Plateau
28RNambe005.1	Rio Nambe above Nambe Reservoir	35.84945	-105.89639	27.5	6864	Arizona/New Mexico Plateau
28Embudo010.1	Embudo Creek above Cannoncito	36.18001	-105.82961	266.7	6302	Arizona/New Mexico Plateau
50PecosR670.3	Pecos R above Tecolote Creek	35.23865	-105.16340	709.3	5500	Arizona/New Mexico Plateau
64PiedrAbvrNav	Piedras River above Navajo Lake	37.04859	-107.41179	331.0	5958	Arizona/New Mexico Plateau
28RGrand725.5	Rio Grande at Ute Mountain blw Rio Costilla	36.93133	-105.73575	7988.5	7403	Arizona/New Mexico Plateau
28Cabres005.4	Cabresto Creek at USGS gage	36.73111	-105.55643	35.9	7890	Arizona/New Mexico Plateau
27RPinos007.3	Rio de los Pinos near Ortiz	36.96000	-106.09000	167.0	8120	Arizona/New Mexico Plateau
48KarrCa002.9	Karr Canyon above Raven Rd	32.92887	-105.81673	8.5	6984	Arizona/New Mexico Mt
57RRuido052.4	Rio Ruidoso atMescalero boundary	33.33634	-105.72288	18.3	7149	Arizona/New Mexico Mt
48ThreeR022.8	Three Rivers at USFS. campground	33.40278	-105.88584	6.7	6319	Arizona/New Mexico Mt
77Turkey001.8	Turkey Creek (at Wilderness Boundary Trail 155)	33.08060	-108.48924	51.2	4870	Arizona/New Mexico Mt
77WFkGil010.0	West Fork Gila at wilderness and cliff dwellings	33.22904	-108.26272	108.6	5746	Arizona/New Mexico Mt
80WhiteW008.8	Whitewater Creek at Catwalk	33.37290	-108.84140	36.6	5180	Arizona/New Mexico Mt
40Alamos058.5	Alamosa Creek below USGS Gage	33.56871	-107.59011	400.9	6135	Arizona/New Mexico Mt
77GilaRi088.0	Gila River 300 meters above Turkey Creek	33.07618	-108.48818	1790.1	4754	Arizona/New Mexico Mt
57RBonit027.7	Rio Bonito at BLM apple orchard near Lincoln	33.52694	-105.45634	223.9	6056	Arizona/New Mexico Mt
77IronCr009.7	Iron Creek at Forest Trail 151	33.37806	-108.56584	8.6	7884	Arizona/New Mexico Mt
77Diamon033.2	Main Diamond Creek at Trail 42	33.28086	-107.84903	5.1	7766	Arizona/New Mexico Mt

Table 1 cont. Nutrient reference sites.

Site ID	Location	Latitude	Longitude	Size (mi^2)	Elevation (ft)	Omernik Level III Ecoregion name
48DogCan002.7	Dog Canyon at Nature Trail	32.74952	-105.91237	10.0	4443	Chihuahuan Desert
41Anima029.3	Las Animas Creek above box	33.04120	-107.55476	89.9	5100	Chihuahuan Desert
60Sittin000.3	Sitting Bull Creek below falls	32.24572	-104.69714	6.2	4675	Chihuahuan Desert
78GilaRi025.5	Gila River below Blue Creek atUSGS gage	32.64927	-108.84679	3196.9	3871	Chihuahuan Desert
79Clanto000.1	Clanton Draw on Gray Ranch			14.93	5085	Chihuahuan Desert
45Mimbre085.7	Mimbres River above Gallinas Creek	32.73056	-107.86667	290	5466	Chihuahuan Desert
60BlackR023.7	Black River near Black River Village	32.20139	-104.25111		3209	Chihuahuan Desert
38RSalad030.0	Rio Salado 1 mile above The Box	34.33912	-107.12325		5233	Chihuahuan Desert
16Seneca000.1	Seneca Crk above Clayton Lake	36.58837	-103.31560	117.0	5344	Southwestern Tablelands
06Canadi322.5	Canadian River at Mills Canyon	36.06694	-104.37215	3777.6	5151	Southwestern Tablelands
05Cimarr041.2	Cimarron River at CS Ranch HQ	36.47200	-104.80106	290.0	6175	Southwestern Tablelands
07Coyote001.7	Coyote Creek above the Mora River	35.91381	-105.16471	242.1	6791	Southwestern Tablelands
10UteCre104.3	Ute Crk above Hwy 102 near Bueyeros	35.95094	-103.69657	768.4	4505	Southwestern Tablelands
	Carrizo	33.30735	-105.66975			Southwestern Tablelands
	Mora River above the Canadian	35.79730	-104.97960			Southwestern Tablelands
02Carriz002.7	Carrizozo Creek near NM406 (DCR 12)	36.88980	-103.00840			Southwestern Tablelands

Table 2. Nutrient test sites

Site ID	Location	Latitude	Longitude	Size (mi^2)	Elevation (ft)	Omernik Level III Ecoregion
42RGrand160.3	Rio Grande below Caballo Dam	32.88473	-107.29195		3999	Chihuahuan Desert
42RGrand115.0	Rio Grande near Rincon at NM 14	32.65445	-107.07584			Chihuahuan Desert
42RGrand001.1	Rio Grande at NM 225 near Anthony, NM	31.99945	-106.63528			Chihuahuan Desert
66Animas027.8	Animas River at Aztec at Hwy 550 bridge	36.8275	-107.9999	1267.6	5597	Arizona/New Mexico Plateau
66Animas018.0	Animas at Flora Vista	36.7914	-108.0752	1324.7	5472	Arizona/New Mexico Plateau
33LaJara009.7	La Jara Creek abv irrigation diversion	36.12769	-106.90425	5.0	8104	Southern Rockies
36RMoqui006.4	Rito Moquino below Seboyetita and Seboyeta Creeks	35.17090	-107.37592	62.1	6089	Arizona/New Mexico Mountain
33NaciCr001.9	Nacimiento Creek @ Eureka Rd.	36.00248	-106.90758			Arizona/New Mexico Plateau
33RPuerc248.7	Rio Puerco @ Hwy 550 Bridge	36.02449	-106.95834	17.9	7480	Arizona/New Mexico Plateau
36Bluewa003.5	Bluewater Crk at mouth of Bluewater Canyon	35.29260	-108.02700	217.6	7290	Arizona/New Mexico Mountain
36Bluewa018.9	Bluewater Creek abv Bluewater Lake @ gage	35.26778	-108.11417	80.1	7411	Arizona/New Mexico Mountain
28RHondo026.9	Rio Hondo 50 feet above WWTP	36.59610	-105.45400	67.5	9281	Southern Rockies
28RHondo026.7	Rio Hondo 300 yards below STP	36.65334	-105.54528		9229	Southern Rockies
28RHondo000.1	Rio Hondo at Rio Grande confluence	36.53440	-105.70800	9.0	6453	Arizona/New Mexico Plateau
48RTular030.0	Rio Tularosa at Gage – Old Hwy	33.14500	-105.89723	129.6		Arizona/New Mexico Mountain
50Gallin102.1	Gallinas River above Las Vegas WWTP	35.56667	-105.21084	199.6	6427	Southern Rockies
50Gallin101.8	Gallinas River 0.25 mile blw Las Vegas WWTP	35.56500	-105.21195	200.0	6417	Southern Rockies
07MoraRi147.1	Mora River above Mora WWTP lagoons	35.96975	-105.30522	163.8	7133	Southern Rockies

A nutrient survey will be conducted at each site according to the *Guidance for Nutrient Surveys* (SWQB 2004). During the survey a number of nutrient and habitat variables will be measured at each site including: water quality, biomonitoring, and channel and substrate characteristics. Qualitative and quantitative habitat measurements will be collected at the time of water quality, periphyton, and benthic macroinvertebrates sampling.

A late summer/fall index period (August 15- to Oct 15) was selected based on review of benthic macroinvertebrate life cycles, their relationship to the hydrograph, monitoring logistics, and various EPA and state guidance documents (Rosenberg and Resh 1993, EPA 1999). Monitoring will be conducted at least 3 weeks after a high flow event as determined by gage data or on-site evidence. Given the short duration of this project, sampling frequencies will be once per year; however, a subset of sites will be selected as long-term monitoring stations representing regional reference sites that have the best available conditions. Long-term monitoring stations will be used to add to the dataset and explore seasonal and year-to-year variability.

2.2 Field Measurement and Sampling Procedures

The following variables will be monitored at each site in accordance with the SOPs and recorded on standardized field forms: 1) periphyton (as benthic chlorophyll *a* concentration, AFDM, and community composition), 2) nutrient concentrations (TP, TN, ammonia, and TKN), 3) ion, total dissolved solids (TDS) and total suspended solids (TSS) concentrations, 4) DO, pH, turbidity, temperature, and conductivity readings and at select sites 3-7 days of hourly recordings of these field parameters, 5) benthic macroinvertebrate community composition, and 6) a number of habitat parameters (velocity, canopy cover, wetted width and depth, approximate gradient, substrate character, and a qualitative habitat and geomorphic assessment). The nutrient survey procedure is provided in the *Guidance for Nutrient Surveys* (SWQB 2004). A summary of the monitoring methods is provided below. For a more detailed description refer to SOPs (NMED/SWQB 2004).

A representative reach is selected that covers approximately two meander lengths. Water quality, biological, and habitat monitoring are conducted within this reach. Water quality monitoring consists of measurement of field parameters (DO, pH, turbidity, temperature, and conductivity) and analysis for nutrient, ion, TDS, and TSS concentrations. Concentrations of Calcium, Magnesium, Potassium, Sodium, Hardness, Alkalinity, Bicarbonate, Carbonate, Chloride, Fluoride, and Sulfate as well as TDS and TSS are determined during ion analysis. Water samples are collected for the analysis of nutrients (TP, TN, ammonia, and TKN) and ions. An YSI® mulitparmeter Sonde is used to measure DO, pH, turbidity, temperature, and conductivity on site.

Biomonitoring consists of collection of a benthic macroinvertebrate and periphyton samples. To collect periphyton, a representative riffle is selected and 10 cobbles are collected along a transect running diagonally through the riffle. For small streams (less than 1 meter wide), 5 cobbles are collected from each of two transects through riffles. If no cobble is available, then woody debris or finer substrate is sampled for periphyton. The periphyton is removed from a known area of each cobble or locations and composited into a single sample (Moulton *et. al* 2002). For benthic macroinvertebrate

collection, three Hess samples are collected from the riffle, avoiding the periphyton transect location and composited into a single sample (EPA 1999).

Habitat monitoring focuses on parameters that influence the growth of periphyton and consists of qualitative and quantitative components. The qualitative components are the Rapid Habitat Assessment (RHA) from EPA's Rapid Biomonitoring Protocols (RBP) (EPA 1999) and the Rapid Geomorphic Assessment (RGA) developed by the USDA National Sedimentation Lab (see forms in Appendix A). The quantitative parameters are cross-sections, canopy cover, pebble counts, average velocity, and an estimate of gradient. Cross-sections consist of wetted width and 5-10 depth measurements taken at the top and bottom of the reach and through the biomonitoring riffle. Canopy cover is measured at 6 locations along each of the three cross-sections: at the right and left banks and left, upstream, right, and downstream in the center of the channel. Average velocity is determined by taking 5-10 measurements at a transect through the riffle where the periphyton was sampled. A pebble count is conducted by measuring 10 pebbles across each of 10 transects throughout the reach. Gradient is estimated by taking 4 clinometer reading, one between every other pebble count transect.

2.3 Sample Handling and Custody Requirements

Samples will be preserved and labeled in the field at the sample location except periphyton samples, which may be processed at the end of the day. Minimum information on the labels includes the date, stream name, and sampling location. Periphyton sub-samples will also include the total sample volume, sub-sample volume, and the analysis to be preformed. This information will also be on all field collection data sheets.

Periphyton samples are either frozen on site with dry ice or kept in the dark emerged in ice until the end of the day, with a maximum holding time of 10 hours (Biggs and Kilroy 2000). At the end of the day, the periphyton samples are either processed or frozen. Periphyton samples are processed by collection of sub-samples that are filtered and frozen for chlorophyll *a* and AFDM analysis or preserved with formalin for community composition determination. The periphyton and filtered samples are kept frozen until they are processed or analyzed.

Water samples for nutrient and ion analysis are collected, cooled to 4°C, stored on ice, and transported in ice chests to the analytical laboratory at the end of the two to five day sampling trip. Sample for nutrient analysis are preserved with 2.5 mL of sulfuric acid per liter.

Benthic macroinvertebrate samples are preserved by adding ninety-five percent ethanol to the sample container to produce a final concentration of approximately 70 percent ethanol with dilution coming from water in the sample matrix and invertebrates. Samples that fill the sample container by more than 50 percent should then be refrigerated overnight, drained, and re-preserved in 95 percent ethanol the next day. A label made from 100 percent cotton fiber bond paper marked by soft pencil or alcohol-proof pen (Pygmy®) accurately describing the sampling location, date, replicate, sample type (HESS, Kicknet), sample habitat (Riffle, Pool, Microhabitat) and collector, is added to the inside

of the bag or jar. The outside of the container should be similarly labeled using a waterproof felt pen (Sharpie®).

2.4 ANALYTICAL METHODS REQUIREMENTS

Refer to detailed SOPs for all methods used in field surveys and laboratory analysis. For additional laboratory methods information refer to *Quality Assurance Project Plan Scientific Laboratory Division Chemistry Bureau Services* (SLD 2005). For physical habitat measures, general references used as background for SOPs were, *Applied River Morphology (*Rosgen 1996) and *Stream channel reference sites: an illustrated guide to field technique* (USFS 1994). For laboratory methods (e.g. AFDM, Chlorophyll *a* determinations), the general references used include *Stream Periphyton Monitoring Manual* (Biggs and Kilroy 2000). For water quality analyses *Standard Methods for the Examination of Water and Wastewater*, 20th Edition (APHA *et. al* 1998) and Code of Federal Regulations (CFR), Title 40: Protection of the Environment, Chapter 1 – Environmental Protection Agency, Part 136 – "*Guidelines Establishing Test Procedures for the Analysis of Pollutants*" (EPA 2000) were used.

2.5 QUALITY CONTROL REQUIREMENTS

Field and laboratory quality control measures include training sessions in habitat surveys prior to each field season, rotation and cross-checks between observers in paired teams to ensure uniformity in how measures are taken and recorded, supervisor oversight of all technicians, use of standardized data forms for all records, and availability of written protocols for all procedures. Replicate samples are collected and checks of field data forms are made at the end of each survey. Contract laboratories for processing of benthic macroinvertebrates and periphyton will adhere to QA procedures provided to and approved by SWQB. Voucher and reference collections will be maintained in designated and centralized collections.

2.6 INSTRUMENT/ EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

The primary equipment employed in the field that require maintenance include: a Marsh-McBirney® flow meter, YSI® multiparamter Sonde and data loggers (YSI Model 6920 Sondes and YSI 650 MDS and 610 Data loggers), Nalgene® manual vacuum pump and GPS units. As needed, this equipment is inspected for proper function, replacement of parts, batteries, and stored at room temperature and dry conditions. All field equipment will be inspected and refurbished as necessary prior to each sampling trip. Results of equipment inspections will be noted in the file for each instrument. Any deficiencies in equipment will be noted in the equipment log in the file and reported immediately to appropriate staff that will recheck the equipment and arrange for repair by the manufacturer or for purchase of a replacement. If condition of equipment is in doubt, it is not used. In the field, extra parts and supplies are carried to attend to malfunctions. Benthic macroinvertebrate collection nets will be checked for tears and repaired as needed. Any damage to the nets will be repaired prior to sampling.

2.7 INSTRUMENT CALIBRATION AND FREQUENCY

Prior to use, instruments are inspected to ensure all components are clean and in good working order. All appropriate probes are activated and set to report. All probes are calibrated prior to sampling trip (at least weekly), and the DO probe is recalibrated to altitude once in the field as needed (at the first site of the day and after every 1000 foot change in elevation). DO probe membrane is checked for bubbles and electrode is examined for corrosion prior to calibration. Membrane and clean silver electrode are replaced as per manufacturer's instructions as needed (see manual). While operation remains normal, other probes should not require further calibration.

2.8 INSPECTION AND ACCEPTANCE REQUIREMENTS FOR SUPPLIES

All shipments are checked to be certain the packing slip is complete and matches the materials ordered (supplies or equipment). Standard supplies are stored in designated areas. Most ordering is from the following sources: VWR International, Fisher Scientific International Inc., Forestry Supplies Inc., and YSI Incorporated.

2.9 DATA ACQUISITION REQUIREMENTS

Most results obtained pursuant to this QAPP involve new data acquired using procedures enumerated in this document and its references and appendices. External and/or historical data acquired for inclusion in these analyses must be references and must meet the QA/QC requirements outlined in this document.

All methods of sample collection, preservation, and analysis used in determining water quality shall be in accordance with approved test procedures published in 40 CFR 136 or any other test procedure(s) accepted by EPA. Test procedures approved under 40 CFR 136 or otherwise accepted by EPA must be referenced.

2.10 DATA MANAGEMENT

Data records are taken on standardized forms for all field and laboratory procedures. Data will be entered into spreadsheets (Microsoft® Excel) and/or a database (Microsoft® Access). Once entered into spreadsheets, a QC check will be preformed by comparing the spreadsheet values to those on the field sheets. Incorrect values will be corrected and suspect values flagged. Site and sample information will also be checked (e.g. latitude and longitude, elevation, date, etc.). Water quality data will be entered directly into the SWQB Water Quality Database and the QC check preformed as described in the SWQB QAPP.

A hardcopy file with raw data and field notes is maintained by SWQB for no less than ten years. This file contains all SLD analytical forms, all non-privileged field notes concerning the investigation, and all QA results for the survey. In addition to water quality data, this file also contains all hard copies of benthic macroinvertebrate, habitat,

fish, pebble count, cross sectional, and periphyton data. Data will be stored on computers and saved to storage media (zip disks or CD). Water quality data will be uploaded to Modernized STORET.

2.11 Assessments and Response Actions

Field sampling and measurement techniques will continually be reviewed in order to determine if changes and/or modifications to the sampling protocols are needed. Decisions to change or alter any protocols or QA/QC measures detailed in this QAPP will be made through consensus of the project team and will be provided to EPA as a revision to this QAPP.

2.12 Reports

A final report will be drafted following the completion of data collections efforts, receipt of all data from laboratory and other contractors, and completion of QA/QC analyses. The draft report will be peer reviewed and considered final after incorporation of all comments received and submittal to the funding agency.

SECTION 3 DATA VALIDATION AND USABILITY

3.1 Data Review, Validation and Verification Requirements

Data review and qualification is overseen by the Project Manager. All site, benthic macroinvertebrate, periphyton and habitat data acquired will be reviewed by the Project Manager using best professional judgment, knowledge of stream ecology, and the QAPP for defining acceptance and qualification (i.e. assignment of validations codes).

3.2 Validation and Verification Methods

Refer to Appendix B of the SWQB QAPP for a detailed description of the data validation process. The Project Manager will be responsible for developing and reviewing data sheets as well as dates, times, reported units, and comments. The Project Manager will screen inaccurate data before they are entered in the database by analyzing all quality control data, including replicates, equipment conditions, and sampling conditions. Quality control sample results will be evaluated individually by performing appropriate mathematical analysis for precision for each sample. All data reports shall include QA/QC information.

3.3 Reconciliation with Data Quality Objectives

Correspondence of data produced with the data quality indicators specified in the QAPP will be reviewed during analysis of data sets. Various corrective actions, as specified in the QAPP and preceding sections, will be used to address any problems detected. Established data quality objectives (DQOs) (see section 1.4) will be compared with the

results of all QA/QC samples. The Project Manager will evaluate completeness, precision, representativeness, and comparability. Data that do not meet DQOs will be flagged in the database. The raw data will be left in the database because it can provide valuable information. If revisions of the QAPP are necessary, this document will be re-drafted and submitted to the appropriate agency QA officers for approval.

REFERENCES

American Public Health Association, American Water Works Association, and Water Environment Federation (APHA *et. al*). 1998. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition.

Biggs, B.J.F. and C. Kilroy. 2000. *Stream Periphyton Monitoring Manual*. NIWA, Christchurch, New Zealand.

Environmental Protection Agency (EPA). 1999. Rapid bioassessment protocols for use in wadeable streams and rivers: Periphyton, benthic macroinvertebrates, and fish. EPA 841-B-99-002. Second edition. Office of Water. Washington, D.C.

_____. 2000a. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. EPA-822-B-00-002.

_____. 2000b. Code of Federal Regulations (CFR), Title 40: Protection of the Environment, Chapter 1 – Environmental Protection Agency, Part 136 – "*Guidelines Establishing Test Procedures for the Analysis of Pollutants*."

Moulton, S. R. II, J. G. Kennen, R. M. Goldstein, and J. A. Hambrook. 2002. Revised Protocols for Sampling Algal, Invertebrate, and Fish Communities as Part of the National Water-Quality Assessment Program. USGS Open-File Report 02-150

New Mexico Administrative Code (NMAC). 2002. *State of New Mexico Standards for Interstate and Intrastate Streams*. 20.6.4. New Mexico Water Quality Control Commission.

New Mexico Environment Department/ Surface Water Quality Bureau (NMED/SWQB). 2004. *State of New Mexico Surface Water Quality Bureau Standard Operating Procedures for Sample Collection and Handling.* Santa Fe, NM

_____. 2005. *Quality assurance project plan for water quality management programs*. . Santa Fe, NM.

New Mexico Scientific Laboratory Division/ Chemistry Bureau Services (SLD). 2005. *Quality Assurance Plan Scientific Laboratory Division Chemistry Bureau Services*. Revision 8, May 18, 2005.

Omernik, J.M. 1987. Ecoregions of the Conterminous United States. *Annals of the Association of American Geographers* 77(1):118-125.

Rosenberg, D.M. and V.H. Resh (eds). 1993. *Freshwater Biomonitoring and Benthic Macroinvertebrates*. Chapman and Hall, New York, NY. 487 pp.

Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology. Pagosa Springs, Colorado.

_____. 1998. The Reference Reach Field Book. Wildland Hydrology. Pagosa Springs, Colorado.

Wolman, M.G. 1954. A Method of Sampling Coarse River-Bed Material. Transactions of American Geophysical Union 35: 951-956.

United States Forest Service (USFS). 1994. *Stream channel reference sites: an illustrated guide to field technique.* General Technical Report RM-245. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.

APPENDIX A. Data Sheets

- Nutrient Survey Equipment Checklist
- Level II Nutrient Survey Form
- Aquatic Vegetation Evaluation Form
- Water Quality Field Sheet
- Cross-Sections Form
- Pebble Count Tally Sheet
- HABITAT ASSESSMENT FIELD DATA SHEET – HIGH GRADIENT STREAMS
- HABITAT ASSESSMENT FILED DATA SHEET – LOW GRADIENT STREAMS
- RAPID GEOMORPHIC ASSESSMENT (RGA) FORM

NUTRIENT SURVEY EQUIPMENT CHECKLIST

Water Quality

- ❑ Clipboard
- ❑ Pencils
- ❑ Sharpies
- ❑ Site list/directions
- ❑ Access authorization documents
- ❑ Field sheets
- ❑ Lab forms
- ❑ Stickers
- ❑ Water carboy (w/DI water)
- ❑ Wash bottles

- ❑ Cubitainers (liters, gallons)
- ❑ Sulfuric acid
- ❑ Pipetters (and repair kit)
- ❑ Pipetter tips

- ❑ Turbidity standard
- ❑ Conductivity standard
- ❑ pH buffers and storage solution
- ❑ Sonde, data logger, cable, & manual
- ❑ Barometer (for sonde deployment)
- ❑ Sonde maintenance kit
- ❑ D.O. probe repair kit
- ❑ Kemwipes
- ❑ Deployment PVC pipe
- ❑ Chains & locks
- ❑ T-post & driver

Habitat

- ❑ Measuring tape
- ❑ Survey Staff
- ❑ Bank pins
- ❑ Hammer
- ❑ Ruler(s)
- ❑ Counter
- ❑ Densiometer

  Clinometer
  Flow meter
  Forms (RGA, RBP, Pebble, X-section, sonde)

General

- ❑ Coolers
- ❑ Extra batteries (AA &C)
- ❑ Cell phone
- ❑ Camera

- ❑ Field notebook
- ❑ Maps
- ❑ Tool box
- ❑ Dry ice (for overnight trips)

Periphyton

- ❑ Tray or basin
- ❑ Toothbrush (bent)
- ❑ Scalpel or knife
- ❑ Delimiter
- ❑ Wash bottle

- ❑ Funnel
- ❑ Sample containers
- ❑ Graduated cylinder

- ❑ Pipetter and tips
- ❑ Glass fiber filters
- ❑ Aluminum foil and sm ziplocks
- ❑ Homogenizer (hand-held blender)
- ❑ Vacuum pump
- ❑ Filter flask
- ❑ Filter funnel and clamp
- ❑ Forceps
- ❑ Formaldehyde

Benthic Macroinvertebrates

- ❑ Hess sampler
- ❑ Surber sampler
- ❑ Kicknet
- ❑ Bucket
- ❑ Sample containers
- ❑ Sieve
- ❑ Ethanol
- ❑ Forceps
- ❑ Labels

Personal/Optional

- ❑ Rain gear
- ❑ Boots/waders
- ❑ Neoprene gloves
- ❑ Hat/sun protection
- ❑ Sunglasses/polarized glasses
- ❑ NMED ID/business cards
- ❑ Binoculars
- ❑ Field guides
- ❑ Flashlight

LEVEL II NUTRIENT SURVEY FORM

Photographs: take photos of the stream, substrate, and riparian area.

Site Location:	
Date of survey:	Investigators:
Description of photo locations and content:	

Site description: note feature that influence the response variables, shaded areas can be filed in after the field visit from the habitat and field forms

Watercress present: Yes No Location:		
Location of springs, wetlands, and upwelling areas**:**		
Turbidity (ntu): m e	Water Color:	Average Depth of riffle: m e
Describe Riparian Corridor:		
Average % canopy cover:	Range of velocities:	
Evidence of recent scouring or deposition: Yes No		
Time since last high (≥bankfull) flow: < 1 month 1-3 months >3 months		
Current flow conditions: 0 1 2 3 4 5		
0 - dry channel (no surface or shallow subsurface water apparent) **1 -** no flow (interrupted pools with no obvious shallow, subsurface flow between isolated pools) **2 -** low flow (little surface or shallow subsurface flow between isolated pools) **3 -** moderate flow (obvious flow, but substantially below bankfull)		

Nutrient sources: Fill out Pollutant Source Documentation form and identify possible sources of plant nutrients to the survey reach.

Field Notes

Sonde: deploy Sonde set to take readings for seven days (3 to 14 days acceptable) fill out and attach Sonde Deployment Form.

Field Notes:

Water Chemistry: collect samples for analysis of total and dissolved plant nutrients.

Algal Sampling: collect samples of benthic algae for analysis of Chlorophyll a concentration, Ash Free Dry Mass, and community composition.

Habitat Sampled:	**Number of replicate filters:**	**Type or area of delimitor:**

Dominant Substrate:	**Subdominant Substrate:**	
Total volume (mL):	**Volume filtered (mL):**	**Volume for ID (mL):**
Field Notes(observations on sample collection**:**		

Benthic Macroinvertebrates: Collect benthic macroinvertebrates from the reach being characterized and a suitable reference site.

Date:	**Sample method:**
Reference site:	
Field Notes:	

Algal Bioassays: Collect 2 gallons of water for limiting nutrient analysis and algal growth potential tests. Attach results when received.

Date collected:	**Date to UNM:**
Field Notes:	

AQUATIC VEGETATION EVALUATION FORM

Site Location:_____

Step	Depth (cm)	Velocity Rank (0-3)	Rock Diam. (mm)	Macro-Algae (0-5)	Periphyton (0-5)	Macro-phyte (0-5)	Anoxic Layer (Y or N)
Type of macrophytes and comments:							

Velocity rating:
0 : minimal flow, 1 : moderate, 2 : fast, and 3: very fast

macrophytes and macro-algae
0 : none present
1 : < 5% coverage
2 : 5-25% cover
3 : 25-50%
4 : 50-75%
5 : >75%

Periphyton
0 : rough with no apparent growth
0.5 : slimy, but biofilm is not visible
1 : thin layer of periphyton is visible
2 : thickness of 0.5-1 mm
3 : 1 mm to 5 mm thick
4 : 5 mm to 20 mm
5 : >20 mm

Nutrient Criteria Dev (2004)

STORET Station ID:

Total samples planned:

full-suite ions:
TDS/TSS only:
TDS/TSS with hard/Fl:
nutrients:
diss. metals with total Hg/Se:
full-suite metals:
fecals:
E. coli:
organics (various):
rads (Gross A B):
rads (Ra 226-228):
cyanides:
other:

Sampling data:

Date/time: _____

Staff: _____

Sonde ID: _____ Data logger ID: _____

Temperature (C): _____

Specific Conductance (uS/cm): _____

Salinity (ppT): _____

DO (Disolved oxygen - mg/L): _____ DO chg. _____

DO at local elev. (%): _____

pH: _____ @ 25C

Turbidity (NTU): _____

Request IDs:

	Environmental samples:	Duplicate samples:	Blanks:
Anions/cations RID:			Do not collect "ions" blanks.
Nutrients:			"Reagent blank" (distilled water, acidified).
Total metals:			Do not collect "total metals" blanks.
Dissolved metals:			"Equipment blank" (distilled water, filtered and acidified).
Other (specify):			
Other (specify):			
Other (specify):			

Field data or sample notes:

Cross-Sections

Stream:	Site description
Date:	Crew:

Cross-section 1 (downstream):

Habitat Type (circle type): Riffle Pool Run/Glide

Wetted Width:								Bio sampling location: Yes No	
Distance fm left bank									
Depth of water									
Velocity(only at bio site)									

Canopy Cover

		center upstream		
left bank	center left	center downstream	center right	right bank

Cross-section 2 (Mid):

Habitat Type (circle type): Riffle Pool Run/Glide

Wetted Width:								Bio sampling location: Yes No	
Distance fm left bank									
Depth of water									
Velocity(only at bio site)									

Canopy Cover

		center upstream		
left bank	center left	center downstream	center right	right bank

Cross-section 3 (Upstream):

Habitat Type (circle type): Riffle Pool Run/Glide

Wetted Width:								Bio sampling location: Yes No	
Distance fm left bank									
Depth of water									
Velocity(only at bio site)									

Canopy Cover

		center upstream		
left bank	center left	center downstream	center right	right bank

On site procedures

The following habitat parameters will be measured at each site:
Channel Cross-sections (at 3 cross-sections)
Canopy Cover (at 3 cross-sections)
Pebble count
Velocity
Stream Gradient

1) Select Study Reach – look at 2 meander lengths and include a good riffle for sampling periphyton and benthic macroinvertebrates
2) Collect water quality field and lab parameters (i.e. sonde readings and water samples for analysis of total nutrients)
3) Bio team - sample periphyton and benthic macroinvertebrates and fill out nutrient survey form
    - Periphyton sample consisted of a composite collected from 10 cobbles
    - Benthic macroinvertebrates sample consists of a composite of 3 Hess or Surbur samples collected from the top of a riffle
4) Habitat team – fill out RGA and RBP form, select location for transects at the top, middle, and bottom of the reach (including one transect through the periphyton sampling location – typically center the reach on the riffle)
5) Habitat team - conduct the pebble count and stream channel cross-section measurements (start at the downstream transect)
    - Measure the wetted width
    - Divide the wetted width by 10, take depth measurements, (at the riffle cross section **only**, take velocity readings in each "window"), for streams under 5 foot width, divide into fewer windows
    - Count pebbles
    - Measure the canopy cover at 6 positions
6) Measure stream gradient between ever other pebble count transect

Form list

Field Sheet – for field parameters and lab stickers
Habitat form
Pebble count tally sheet
RGA form
RBP form
Nutrient Survey Form

PEBBLE COUNT TALLY SHEET

Site Name: _____

Date: _____ Crew: _____

	Median	Range (mm)		COUNT	Bed Material Data TOTAL #	ITEM %	% CUM
Silt/Clay	0.01	<.062	**S/C**				
Very Fine	0.02	.062 - .125	**S**				
Fine	0.19	.125 - .25	**A**				
Medium	0.38	.25 - .50	**N**				
Coarse	0.75	.50 - 1.0	**D**				
Very Coarse	1.50	1.0 - 2					
Very Fine	3.00	2 - 4					
Fine	5.00	4 - 5.7	**G**				
Fine	7.00	5.7 - 8	**R**				
Medium	10.00	8 - 11.3	**A**				
Medium	14.00	11.3 - 16	**V**				
Coarse	20.00	16 - 22.6	**E**				
Coarse	28.00	22.6 - 32	**L**				
Very Coarse	40.00	32 - 45	**S**				
Very Coarse	56.00	45 - 64					
Small	80.00	64 - 90	**C**				
Small	109.00	90 - 128	**O**				
Large	154.00	128 - 180	**B**				
Large	218.00	180 - 256	**L**				
Small	309.00	256 - 362	**B**				
Small	438.00	362 - 512	**L**				
Medium	768.00	512 - 1024	**D**				
Lrg-Vry Lrg.	1500.00	1024 - 2048	**R**				
BEDROCK	3000.00						
			TOTALS				

Gradient between transects**:**			
1 and 3	3 and 5	5 and 7	7 and 9

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS

STREAM NAME	LOCATION	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ TIME _____ AM PM	REASON FOR SURVEY

Habitat Parameter	Condition Category			
	Optimal	**Sub optimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	Condition Category			
	Optimal	**Sub optimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score _____

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS

STREAM NAME	LOCATION	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ TIME _____ AM PM	REASON FOR SURVEY

Habitat Parameter	Condition Category			
	Optimal	**Sub optimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score _____

RAPID GEOMORPHIC ASSESSMENT (RGA) FORM

CHANNEL STABILITY RANKING SCHEME

Station Name_____

Station Description_____

Date_____ Crew_____ Pebble count taken: Y / N

Pics (circle): u/s, d/s, x-sec, LB, RB Slope_____ Pattern: meander/ straight/ braided

1. Primary bed material

Bedrock	Boulder/Cobble	Gravel	Sand	Silt/Clay
0		1	2	3

2. Bed/bank protection

Yes	No	(with) 1 bank protected	2 banks protected
0	1	2	3

3. Degree of incision (relative elev. of "normal" low water if floodplain/terrace is 100%)

0-10%	11-25%	26-50%	51-75%	76-100%
4	3	2	1	0

4. Degree of constriction (relative decrease in top-bank width from up to down stream)

0-10%	11-25%	26-50%	51-75%	76-100%
0	1	2	3	4

5. Streambank erosion (dominant process each bank)

	None	fluvial	mass wasting (failures)
Inside or left	0	1	2
Outside or right	0	1	2

6. Streambank instability (percent of each bank failing)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	0	0.5	1	1.5	2
Outside or right	0	0.5	1	1.5	2

7. Established riparian vegetative cover (woody or stabilizing perennial grasses each bank)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	2	1.5	1	0.5	0
Outside or right	2	1.5	1	0.5	0

8. Occurrence of bank accretion (percent of each bank with fluvial deposition)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	2	1.5	1	0.5	0
Outside or right	2	1.5	1	0.5	0

9. Stage of channel evolution (I and VI generally < 11 total score)

I	II	III	IV	V	VI
0	1	2	4	3	1.5

10. SUM OF ALL VALUES _____ ▶ [ ]